Can CERES help constrain the cloud feedback?

Stephen Po-Chedley and Nick Siler

CERES Science Team Meeting
University of Washington

September 2, 2015

Outline

- Emergent constraints
- Constraint from SW CRE
- Comments
- Summary

Emergent constraints

emergent constraint

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Emergent Constraints on. Earth System Sensitivities. Peter Cox. Professor of Climate System Dynamics. University of Exeter. How can we constrain. long-term ...

[PDF] Peter Cox
www.mathclimate.org/sites/default/files/Cox_ICMS2013.pdf
➢**Emergent Constraint** : a relationship between an. Earth System sensitivity to anthropogenic forcing and an observable (or already observed) feature of the ES.

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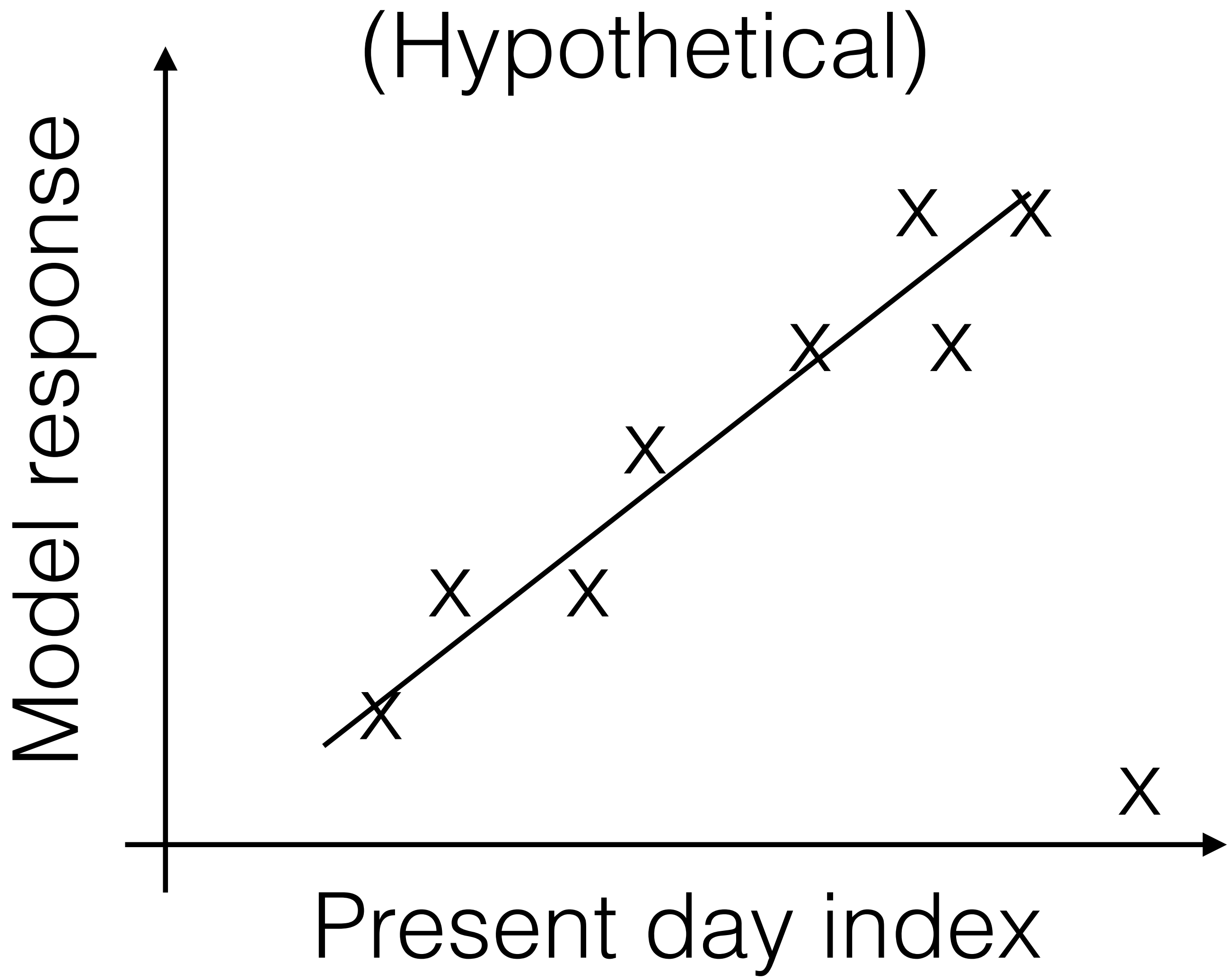
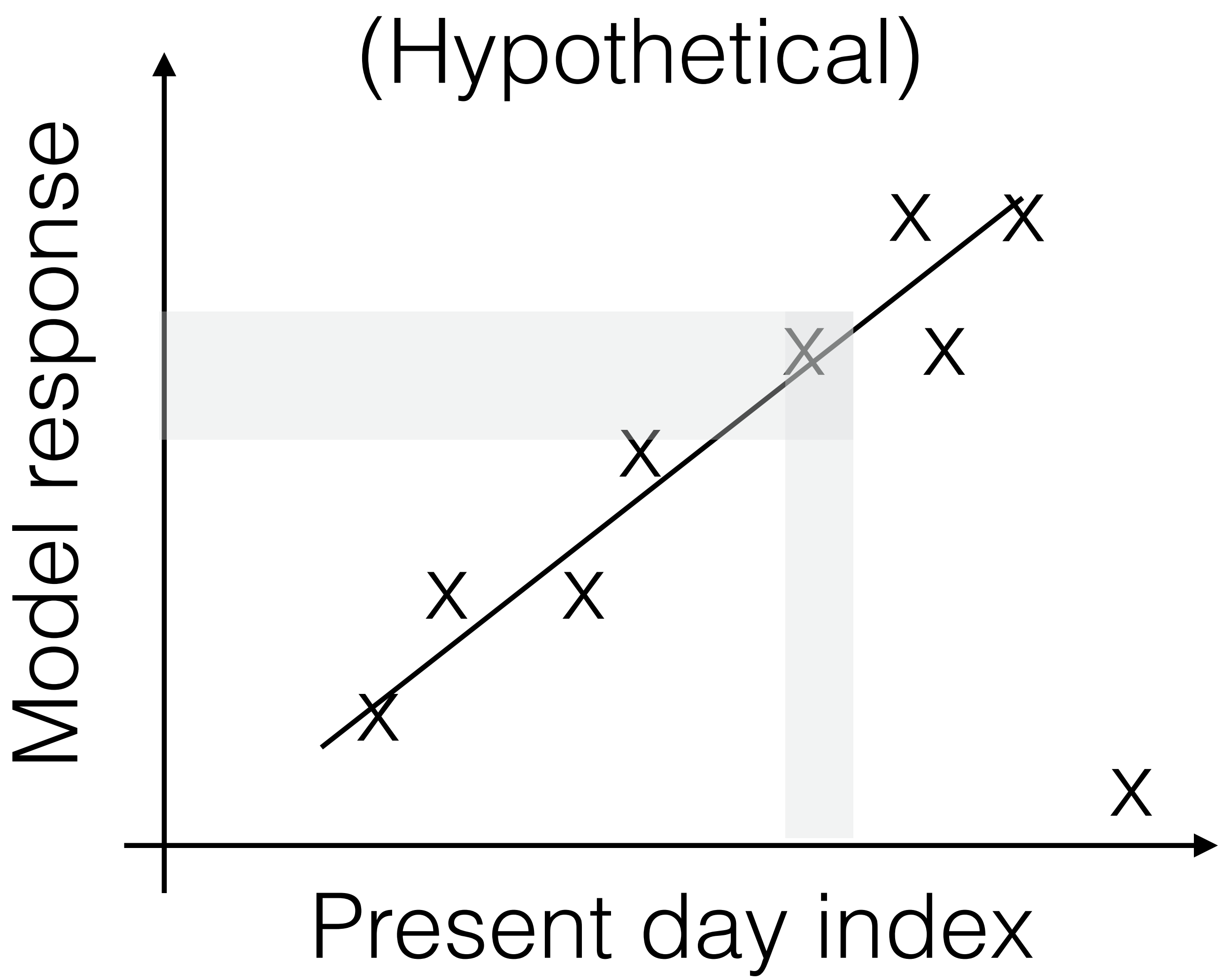
Emergent constraints



Emergent constraints



Emergent constraints

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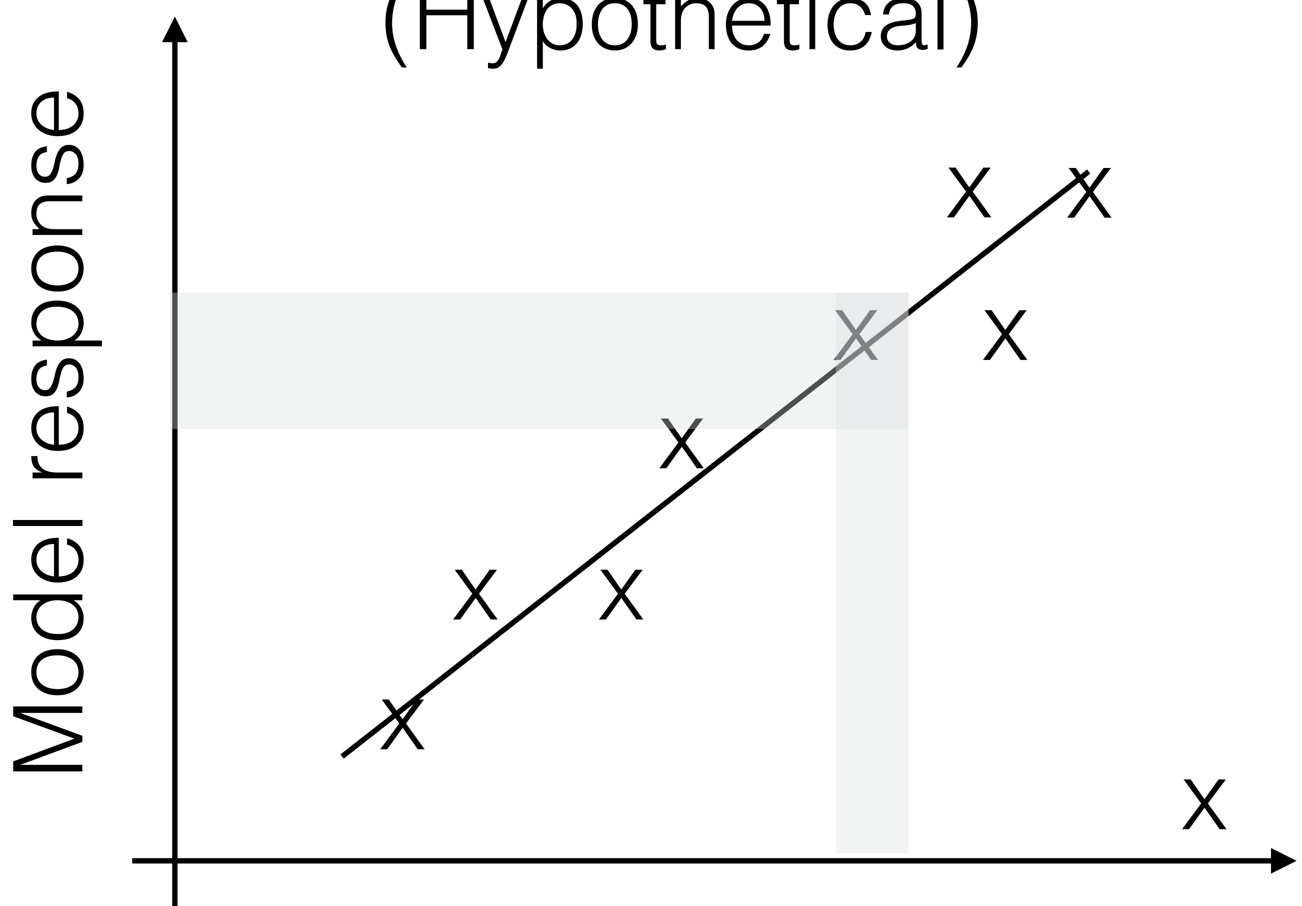
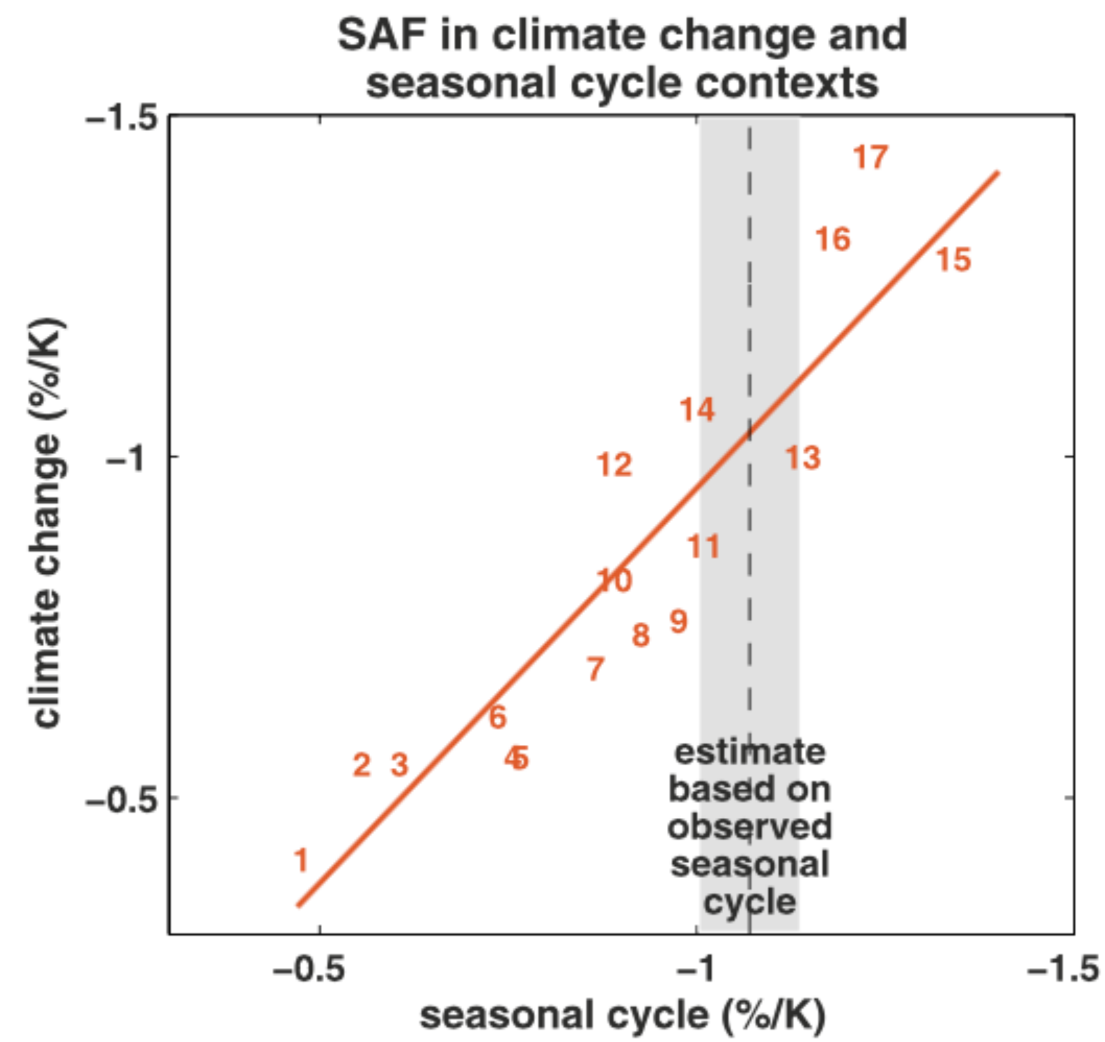
(Hypothetical)

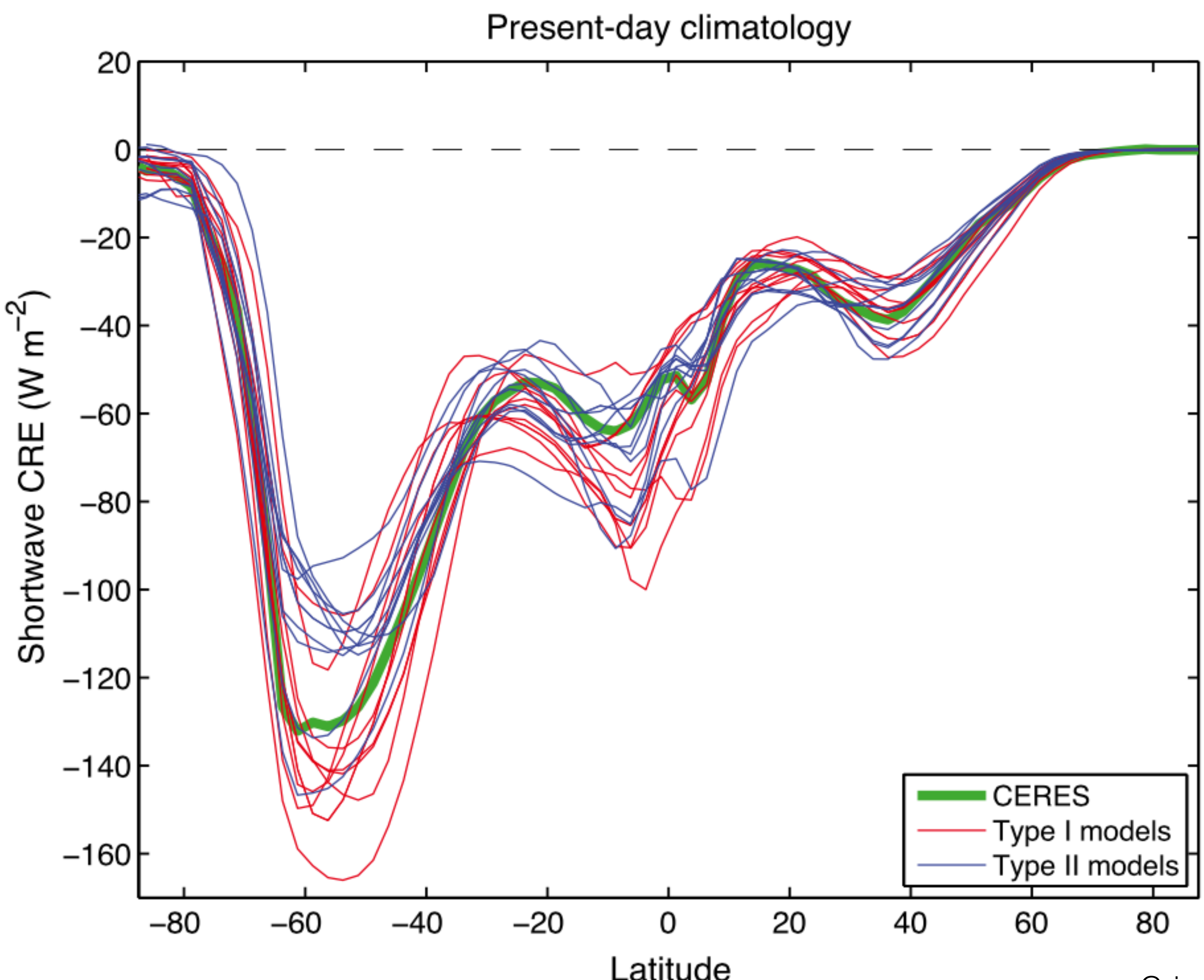


Snow albedo feedback



Hall and Qu, 2006

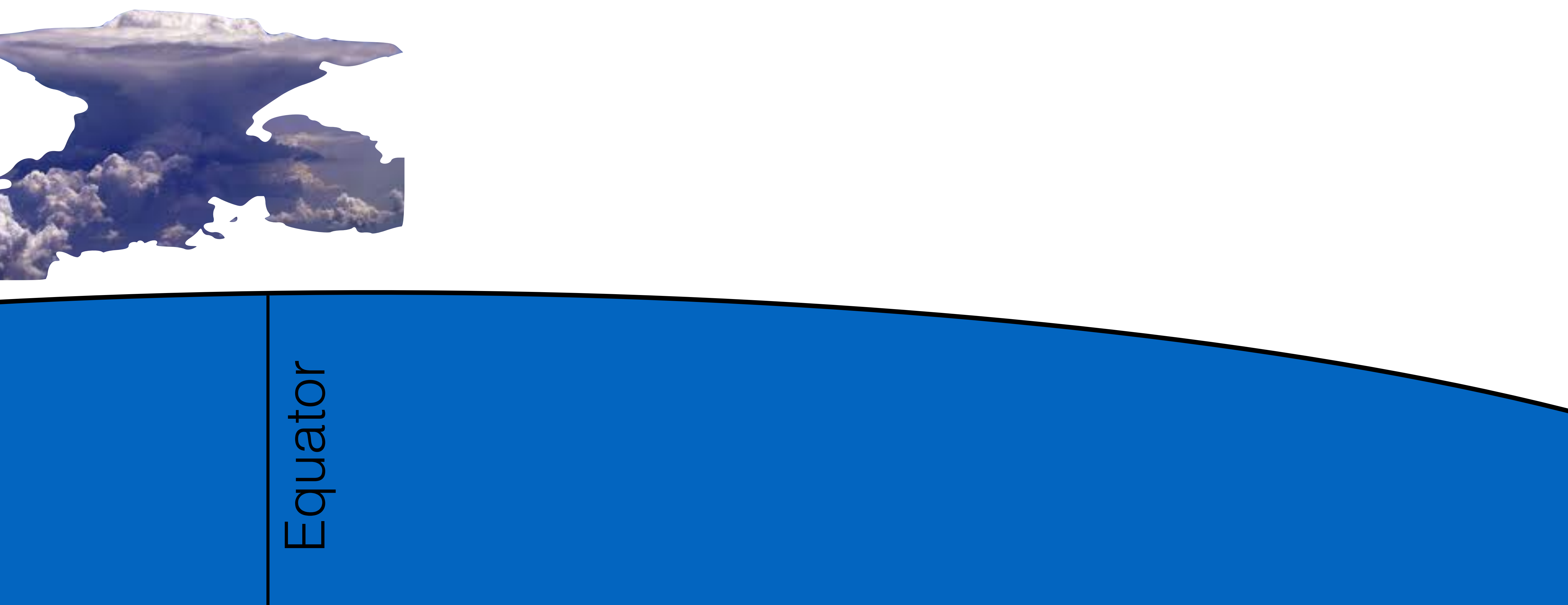
Emergent constraints



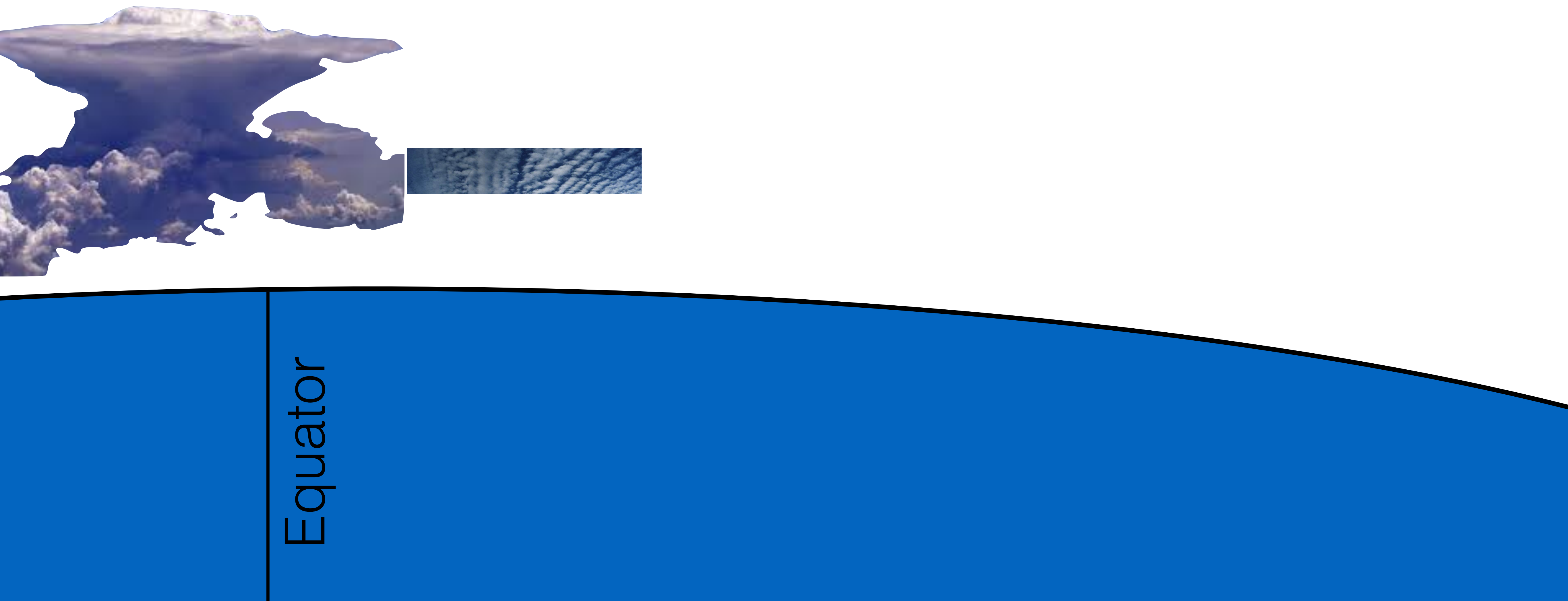
Grise and Polvani, 2014

Emergent constraints

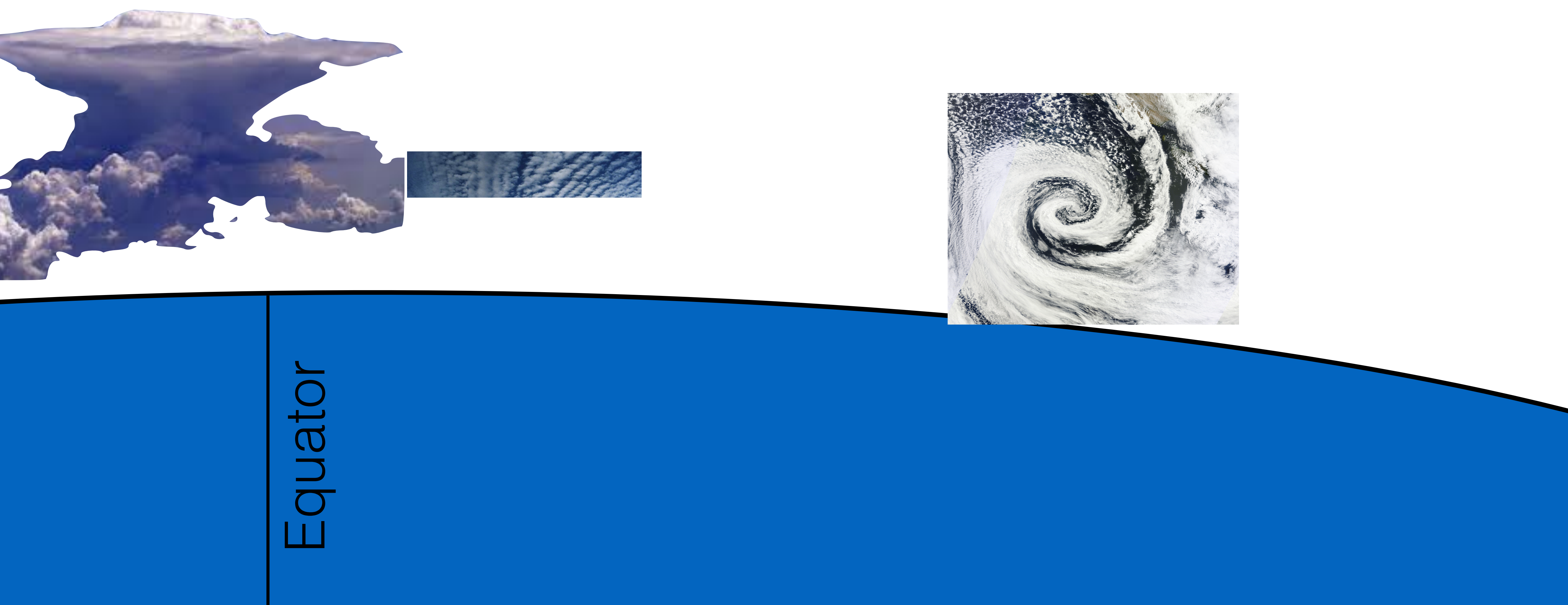
Emergent constraints



Emergent constraints



Emergent constraints



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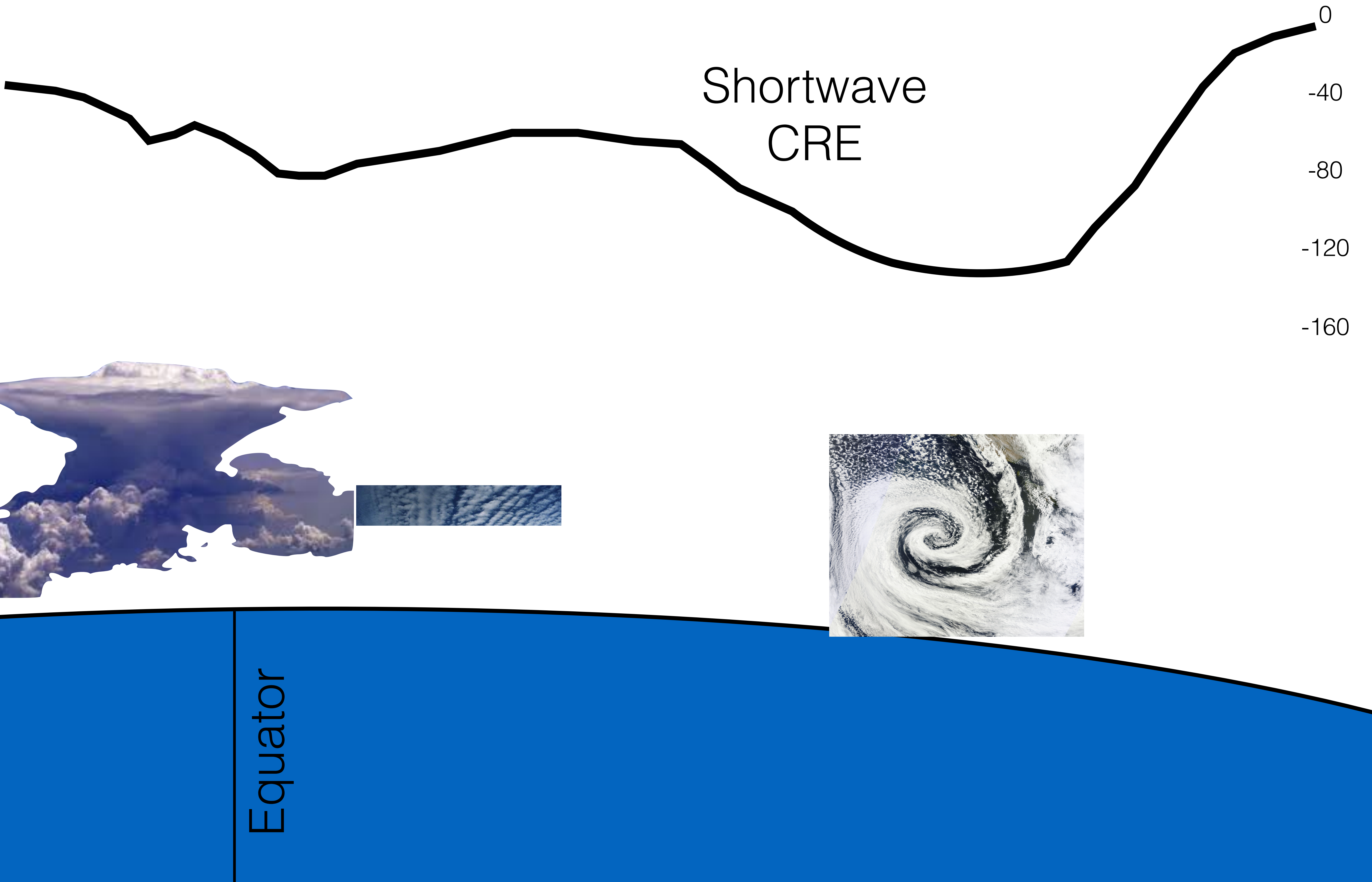

Emergent constraints

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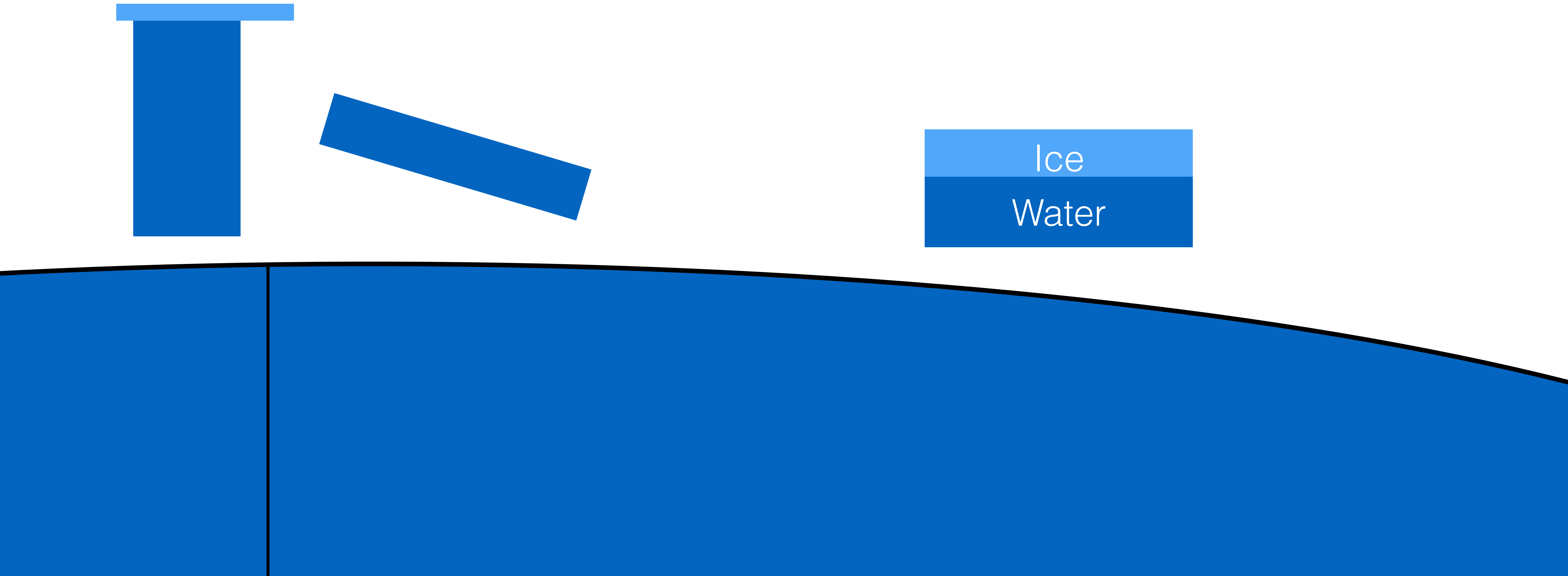

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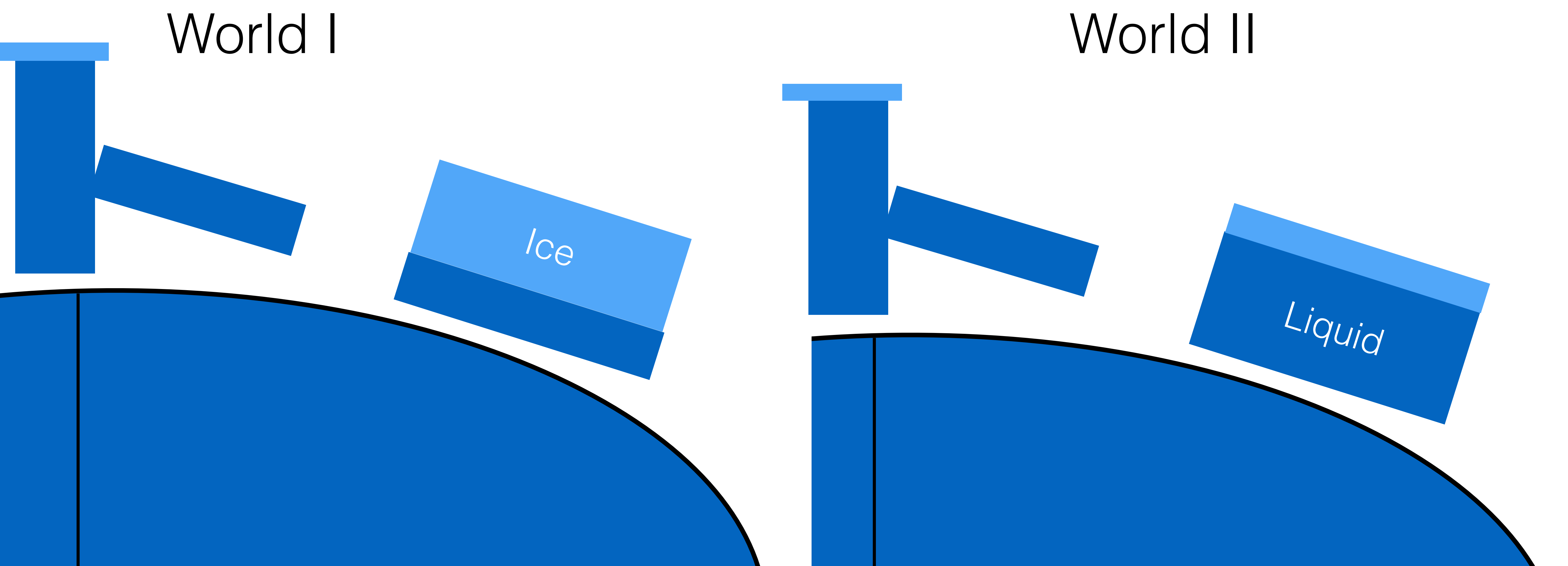
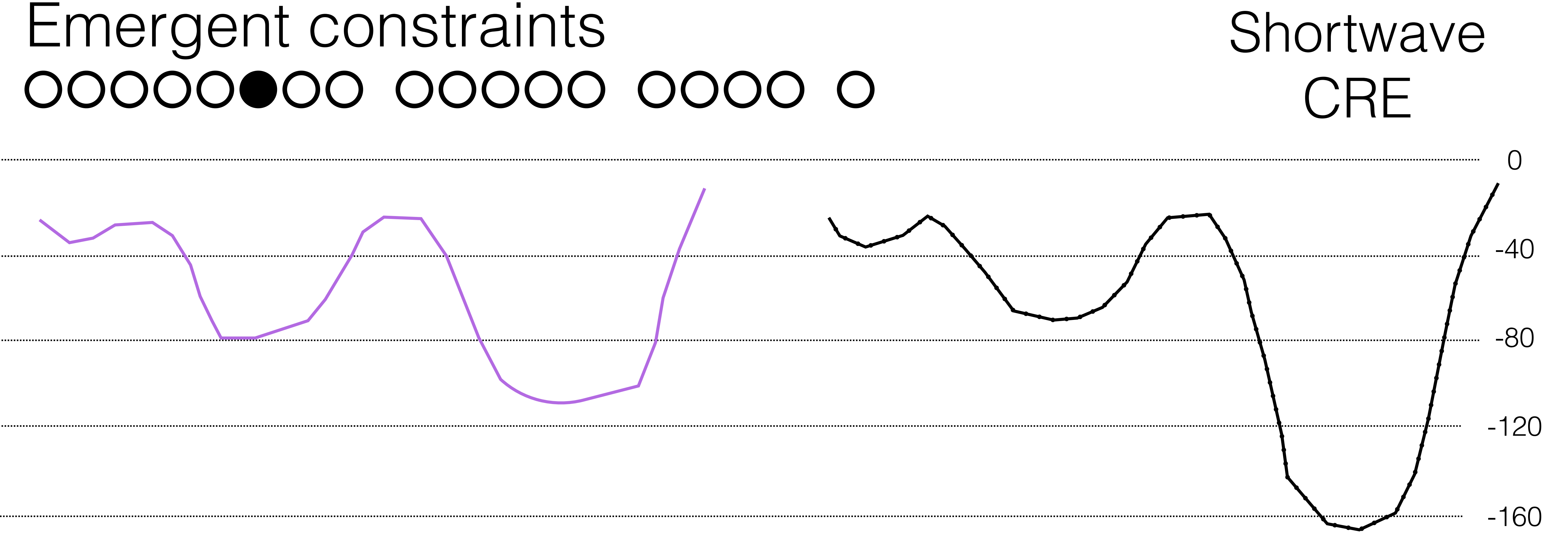
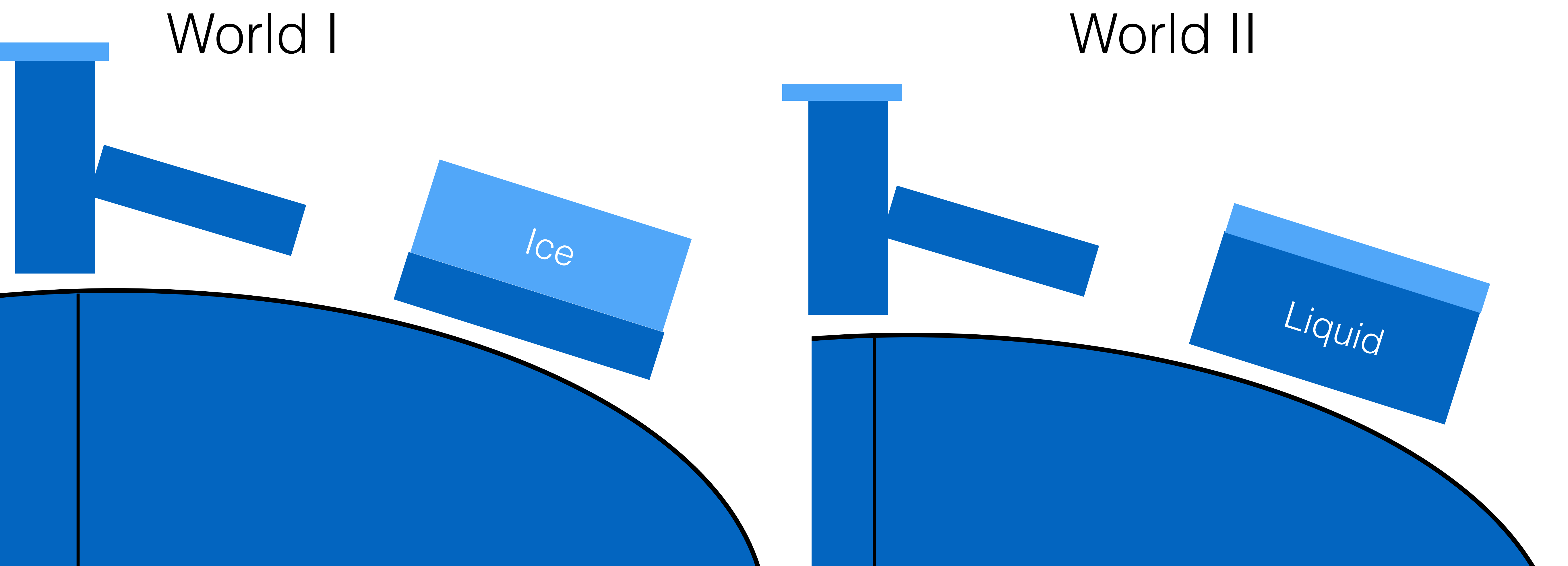


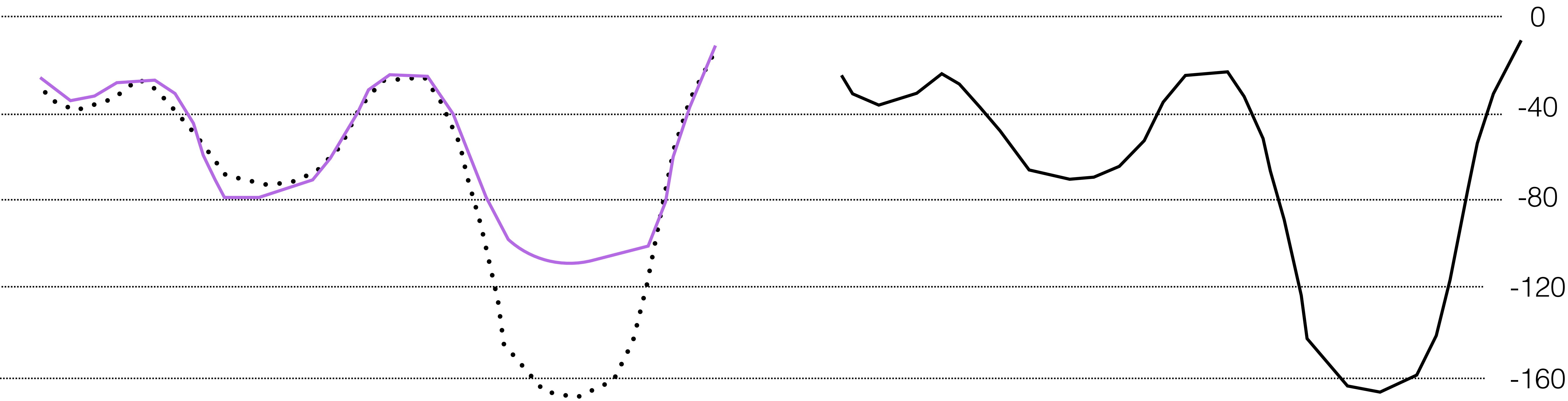
Emergent constraints

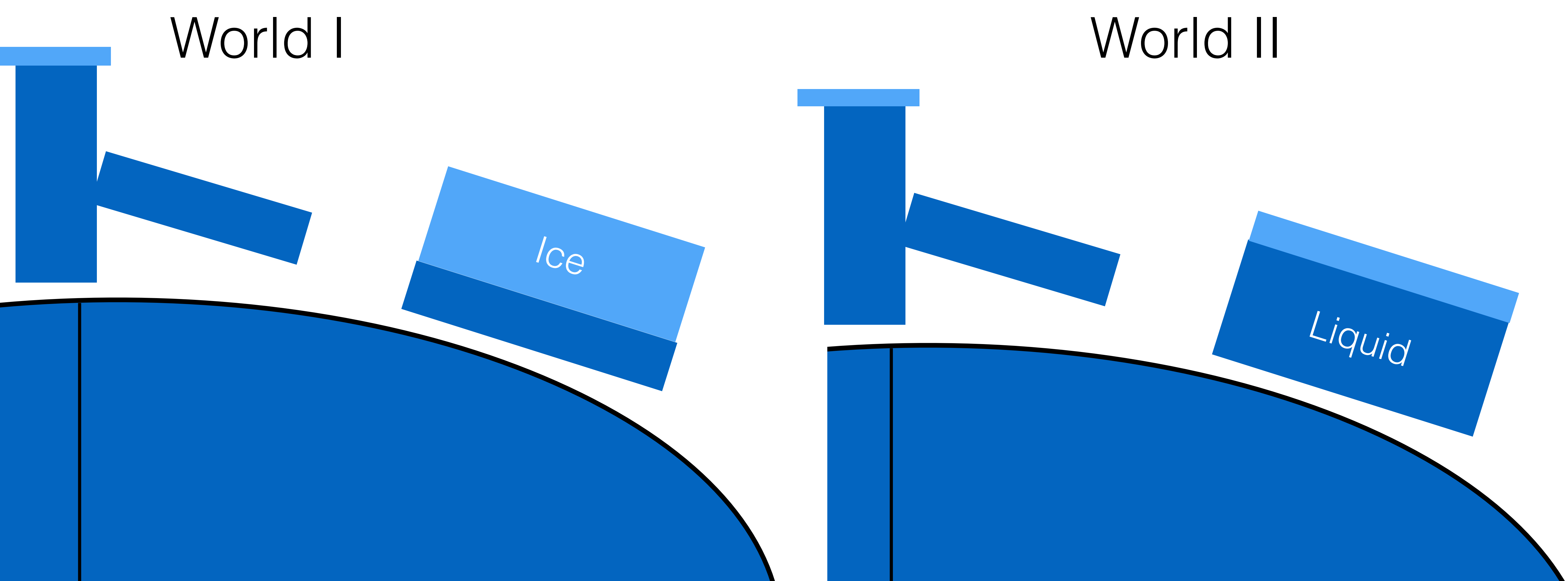




Emergent constraints

Shortwave CRE





Emergent constraints

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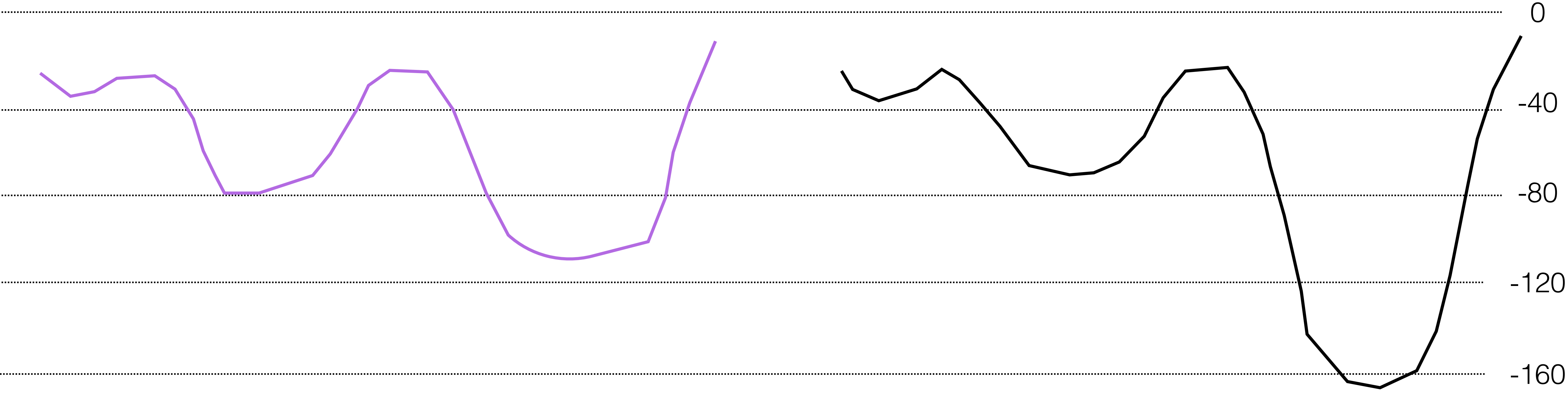
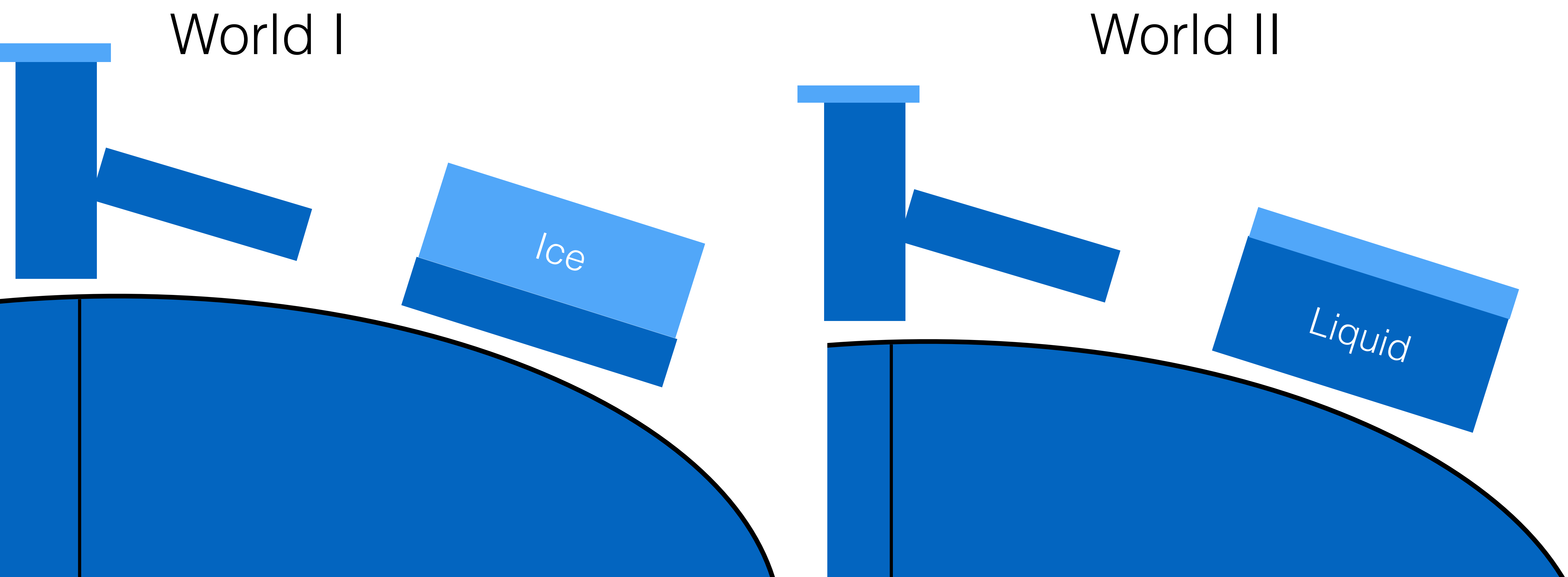
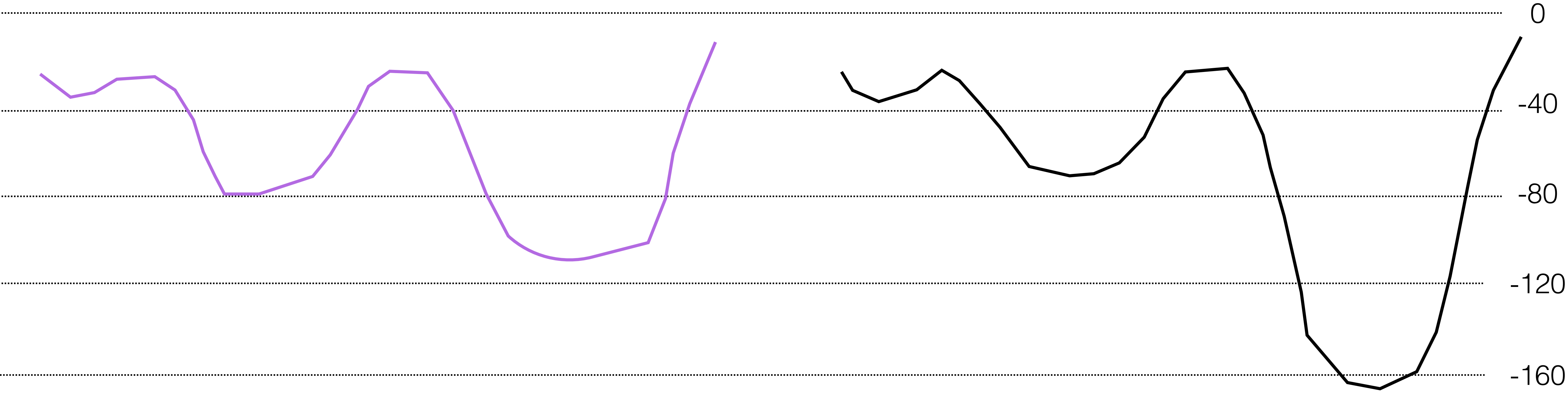
Shortwave CRE



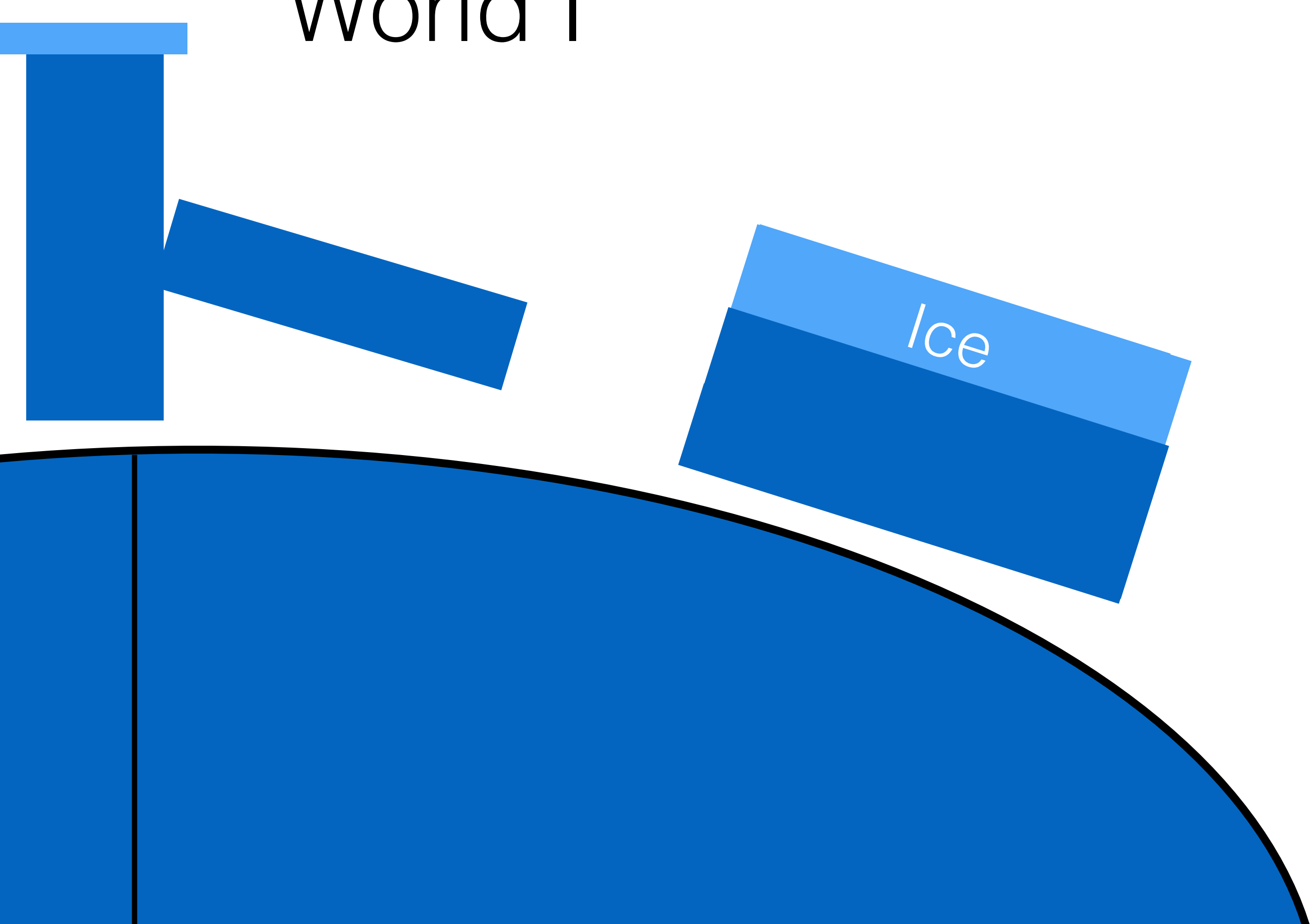


Emergent constraints

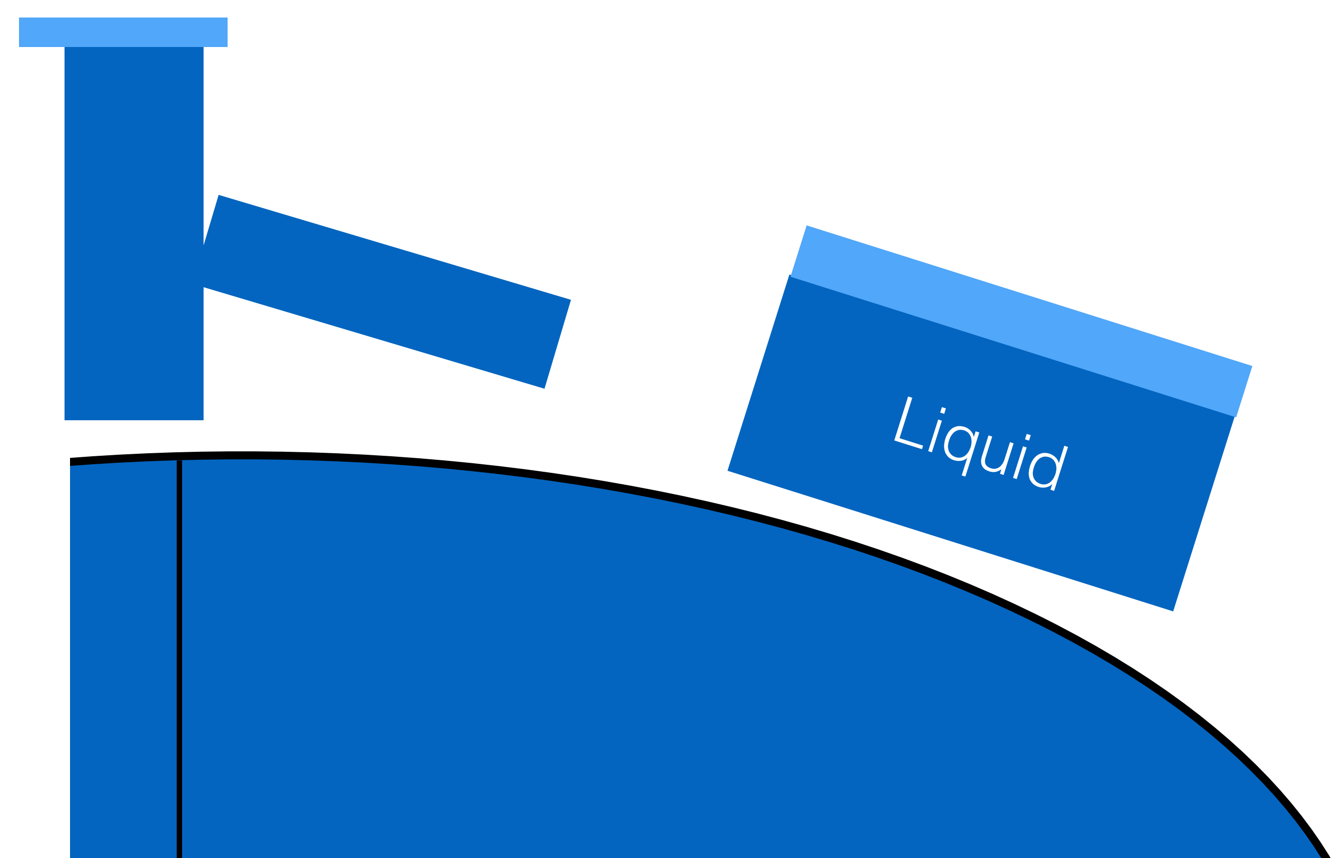
Shortwave CRE



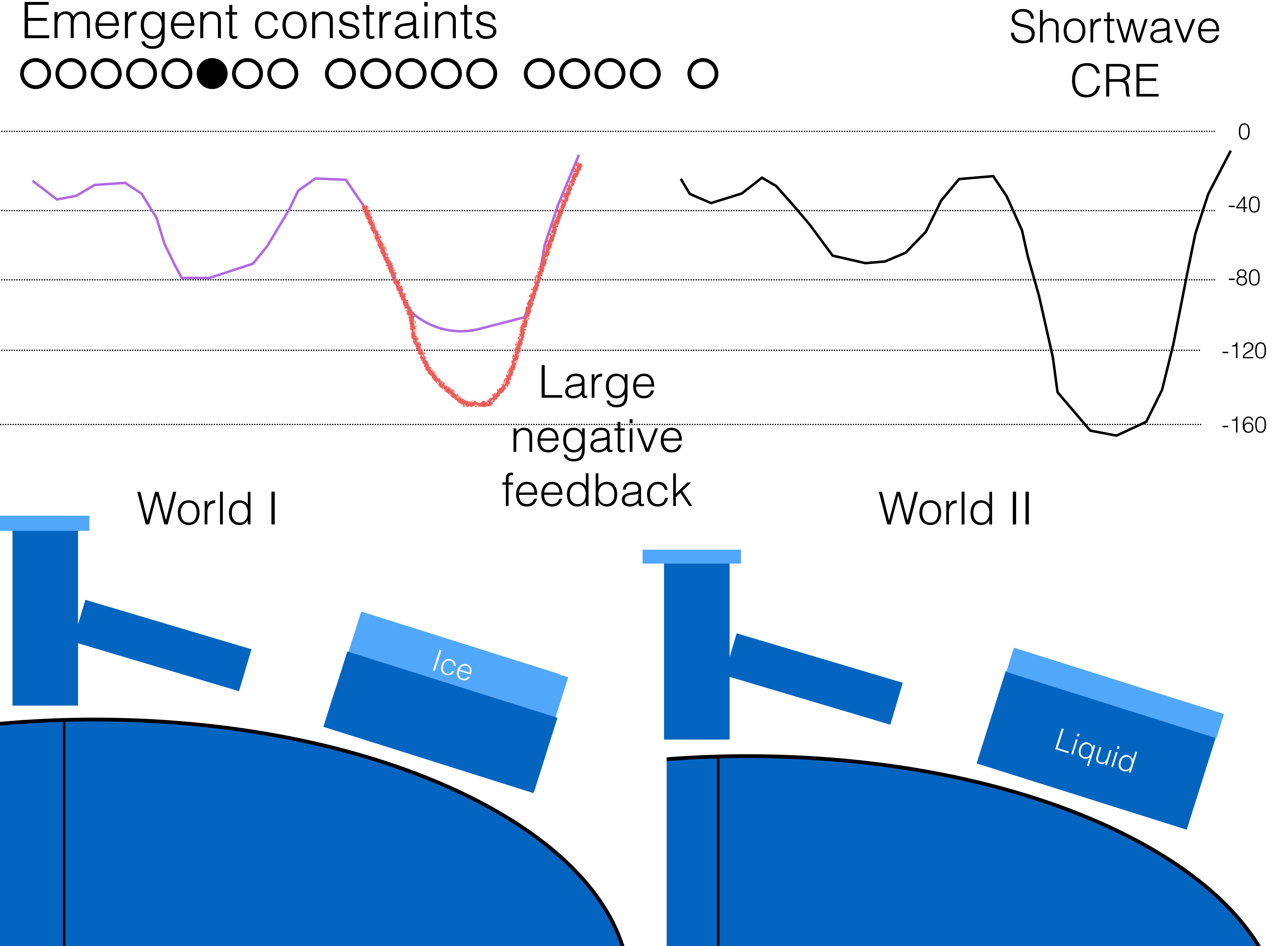
World I



World II

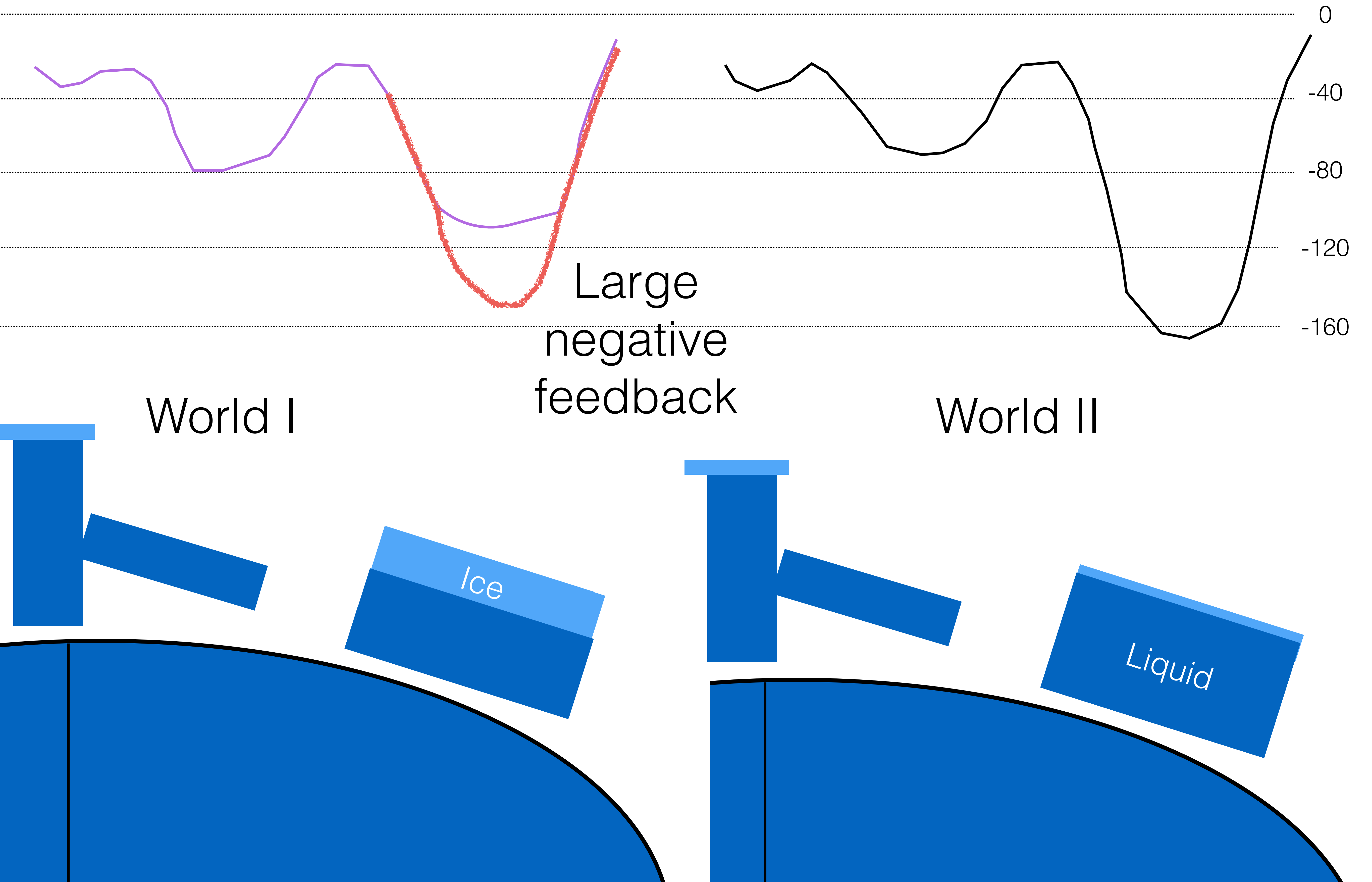


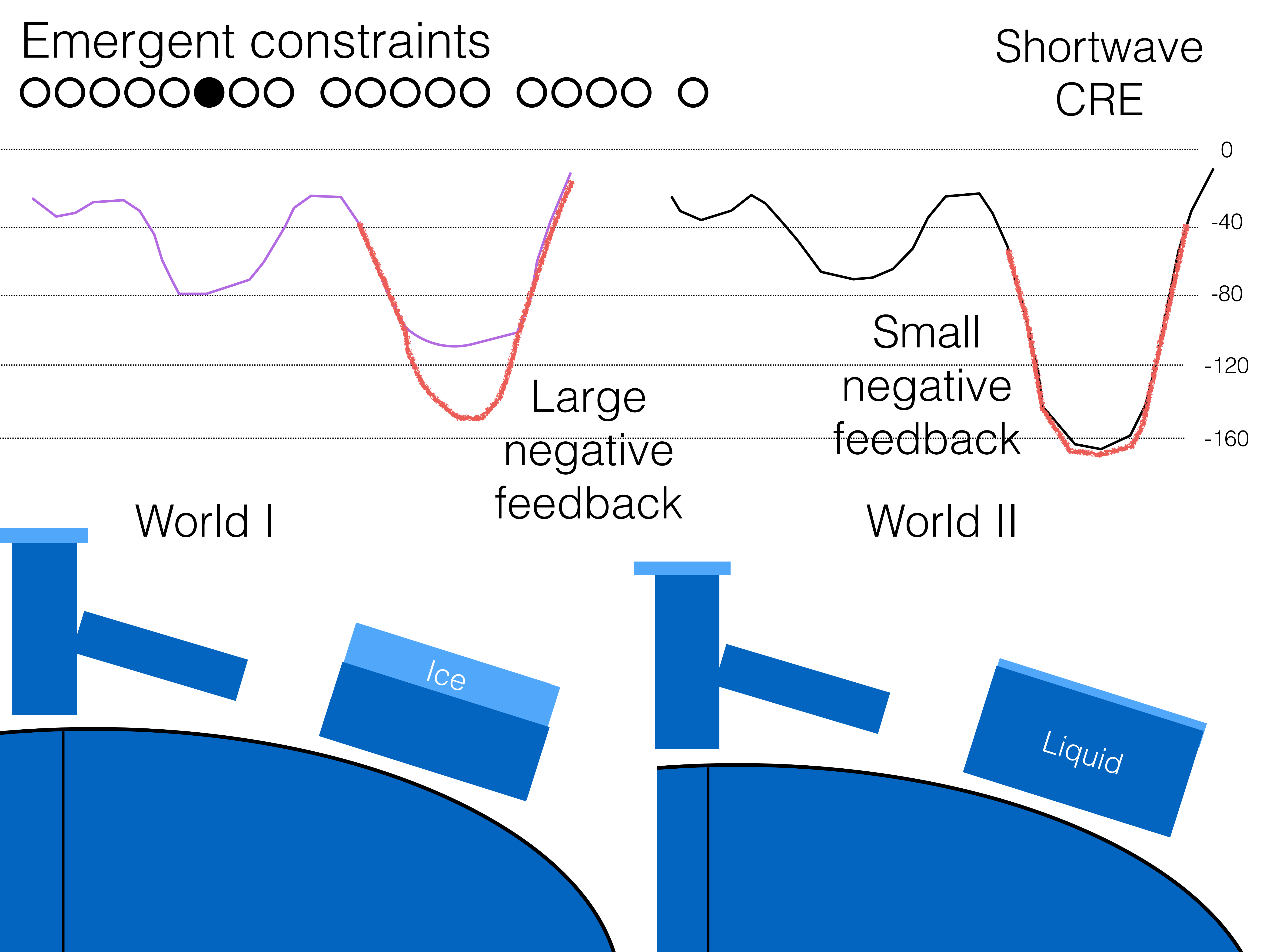
Emergent constraints



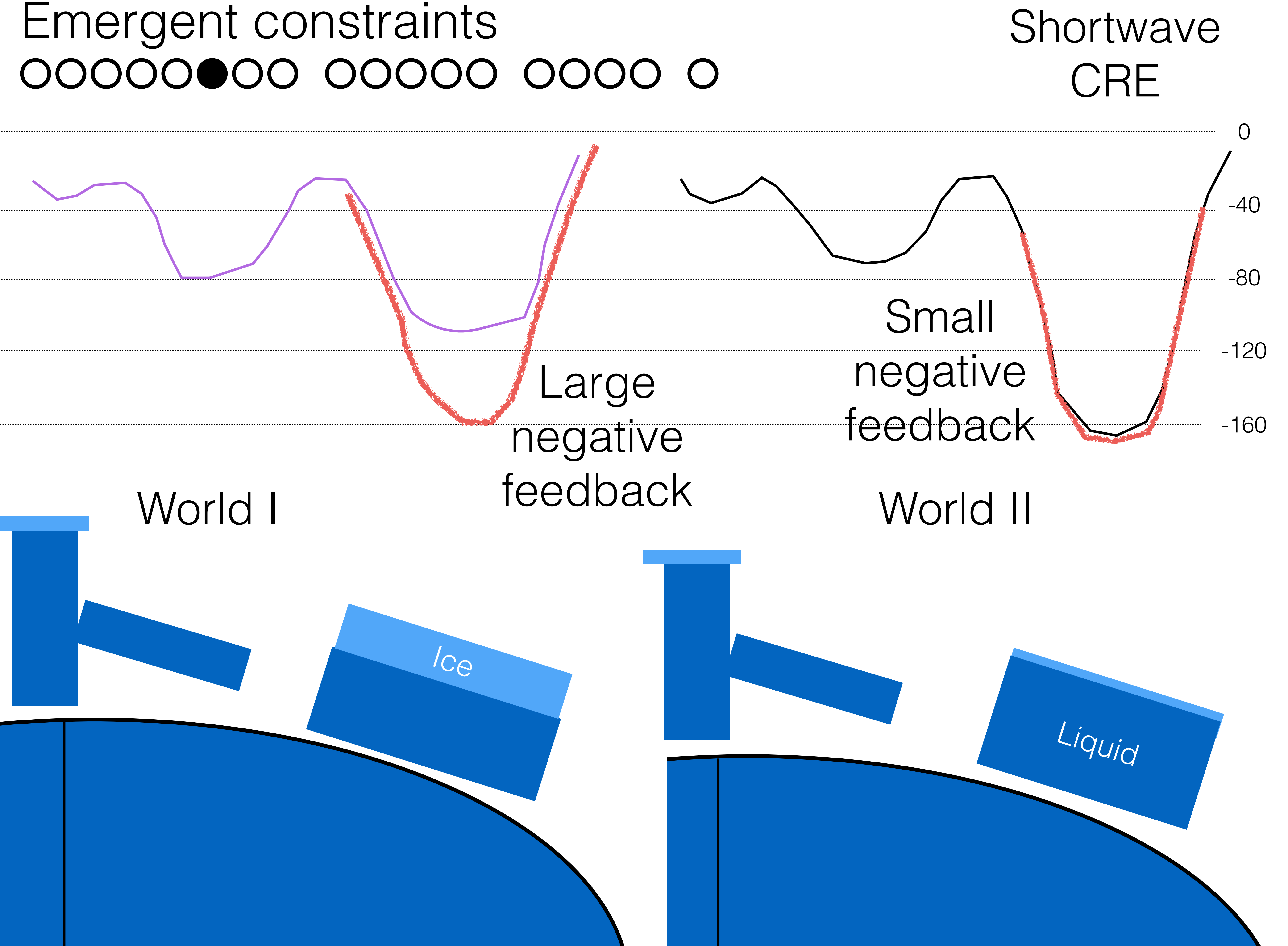
Emergent constraints

Shortwave CRE



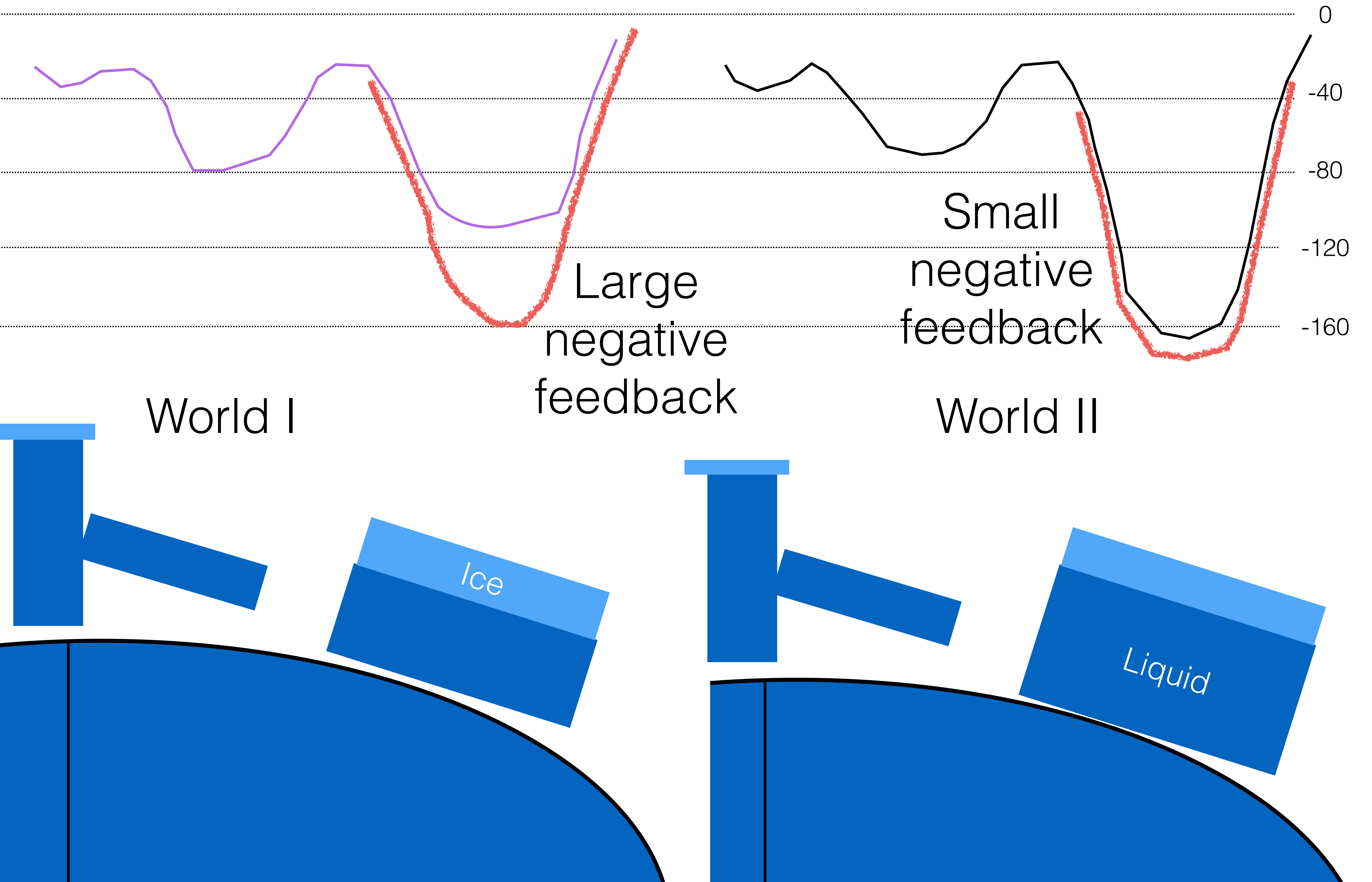

Emergent constraints
Shortwave
CRE
0
-40
-80
-120
-160
Small
negative
feedback
Large
negative
feedback
World I
World II
Ice
Liquid

Emergent constraints



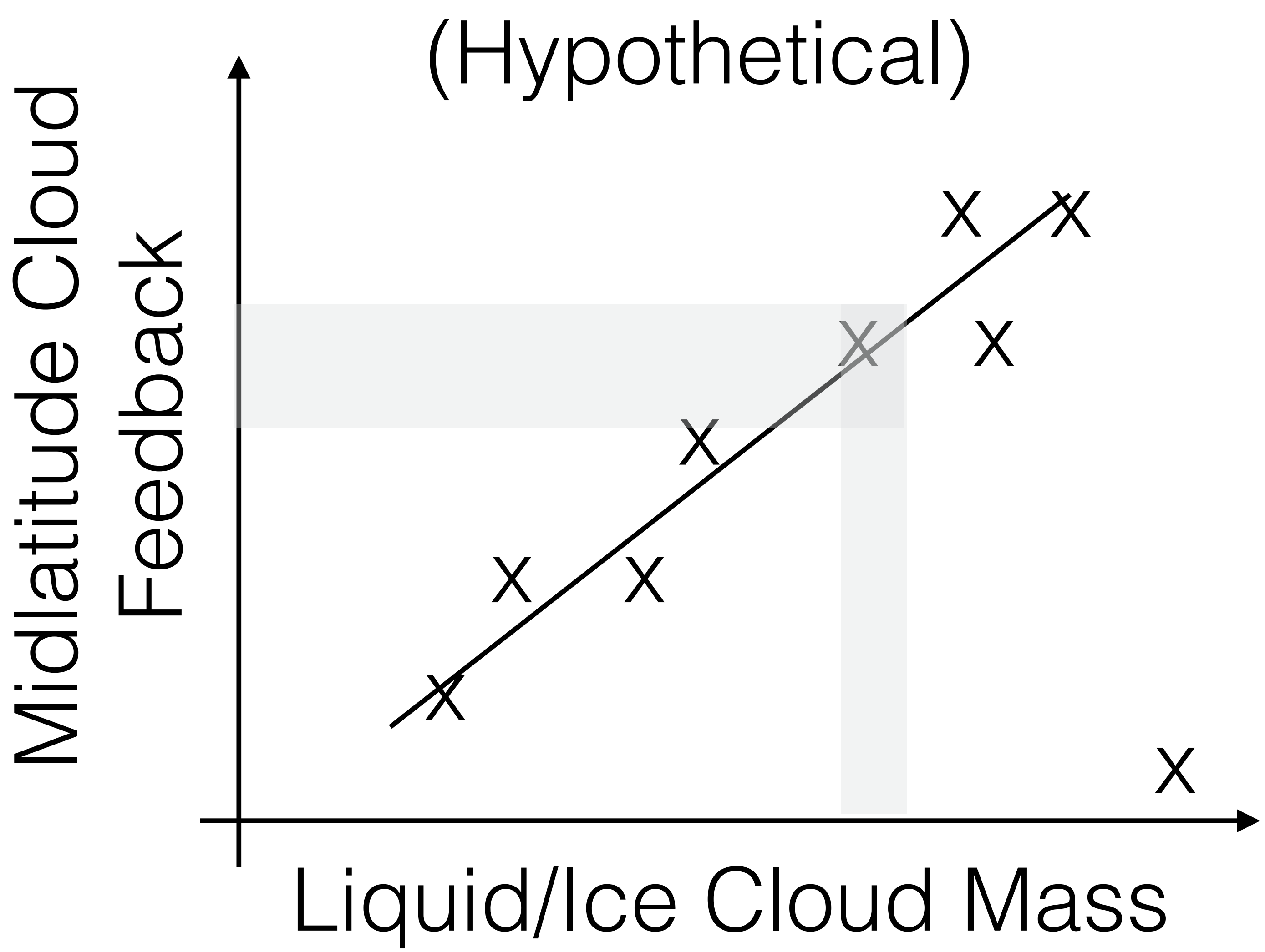
Emergent constraints

Shortwave CRE



Emergent constraints

- Midlatitude clouds introduce potential constraint on cloud feedback in these regions (via analysis of reflected shortwave and liquid/ice water path)



suggested by McCoy et al., 2015

Emergent constraints

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- Ice-liquid partitioning (or just mean cloud liquid water) (McCoy et al., 2015)
- Mean state shallow/deep mixiness (Sherwood et al., 2014)
- Tropical/subtropical relative humidity/cloudiness (Volodin, 2007; Sherwood et al., 2010; Fasullo and Trenberth, 2012; Bony and DuFresne 2005)
- Midlatitude jet shift (Grise and Polvani, 2014) or maybe not (Wall and Hartmann, 2015)

Constraint from SW CRE

- See where mean-state SW CRE projects most strongly onto the global cloud feedback (via partial least squares)
- Use AMIP models, which have same surface temperature distribution (more of an apples-to-apples comparison with observations)

Constraint from SW CRE

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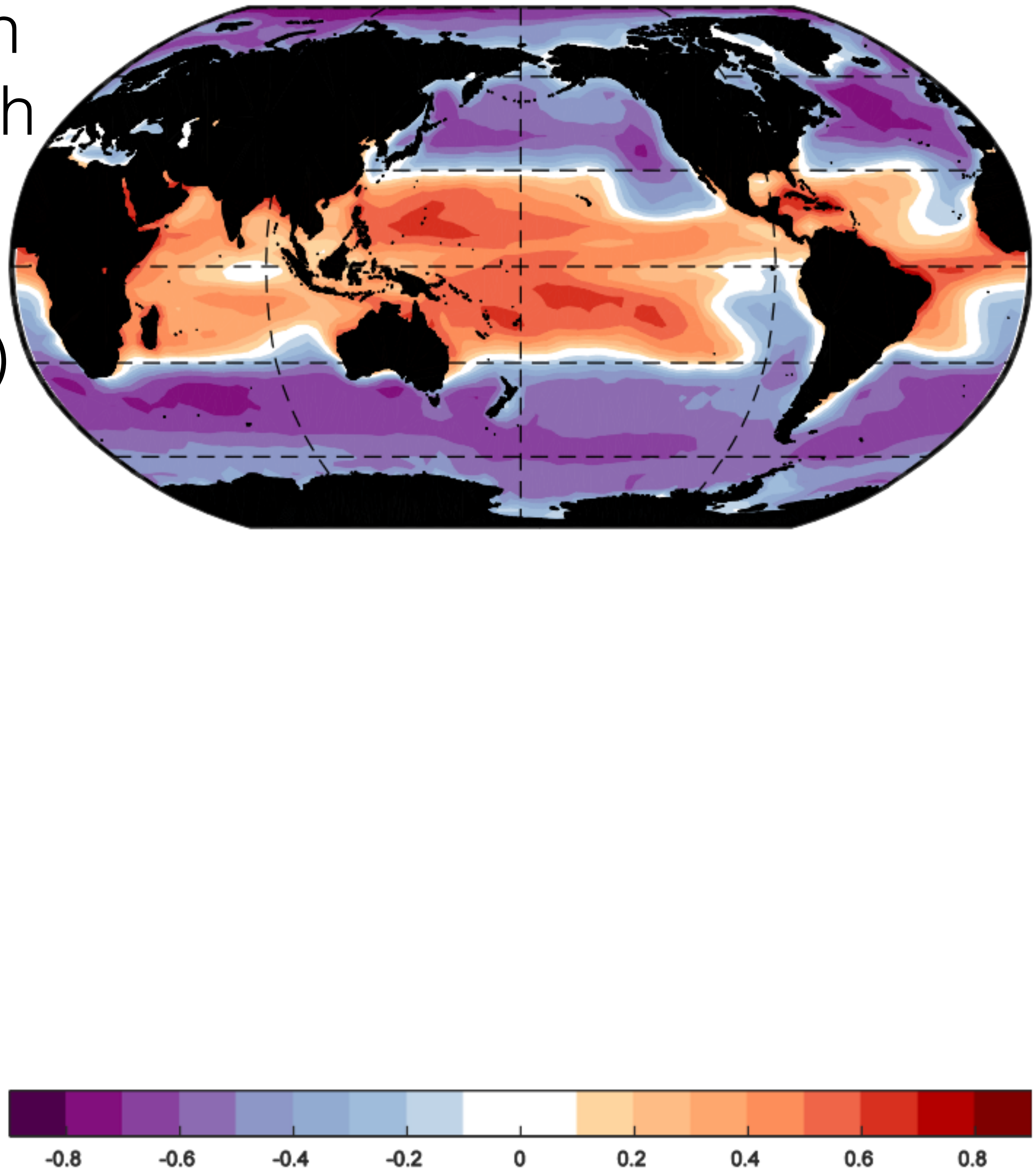
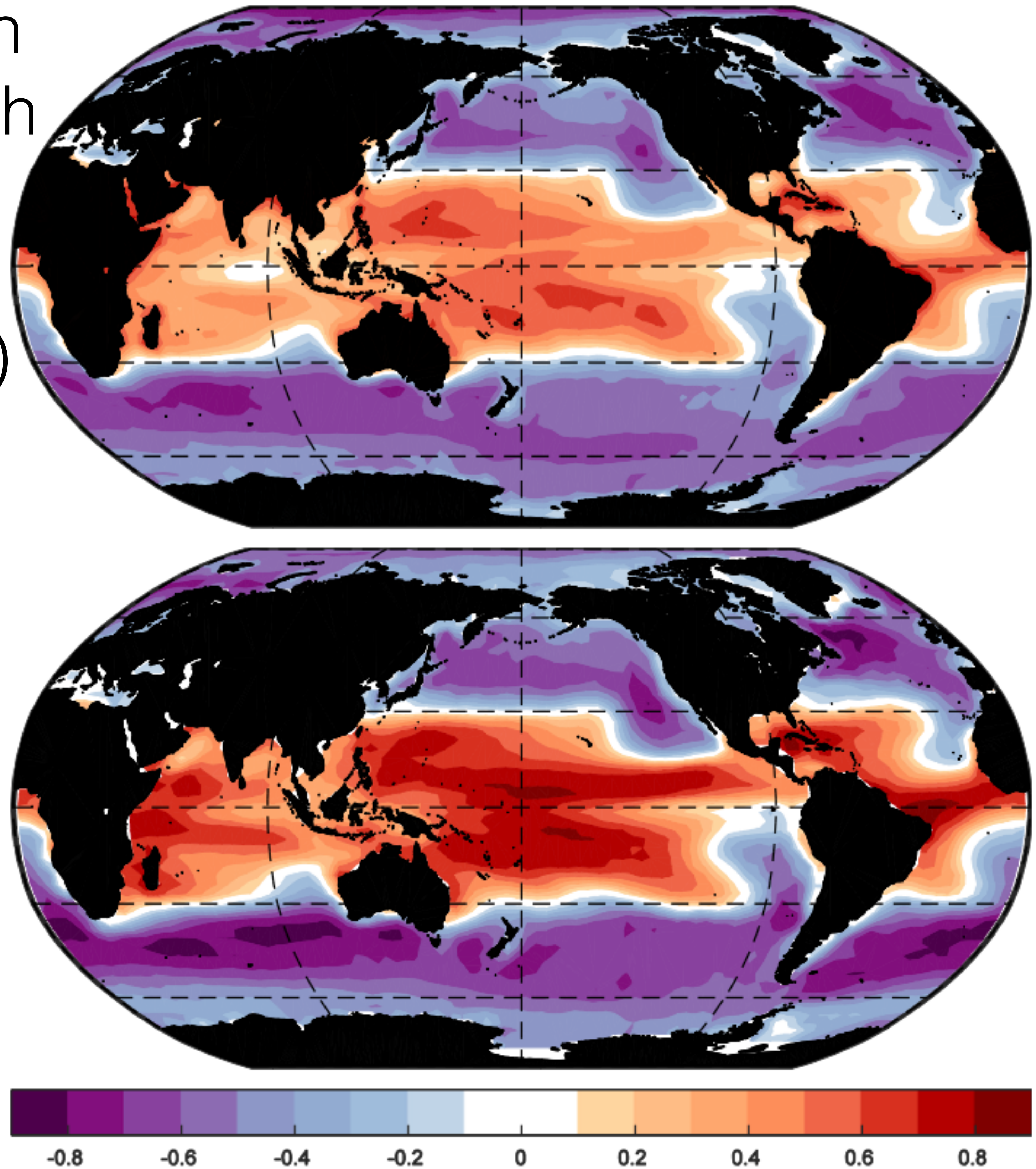
r-value between SW CRE in each model and the global cloud feedback (PLS)



Constraint from SW CRE

r-value between SW CRE in each model and the global cloud feedback (PLS)

leading EOF of SW CRE

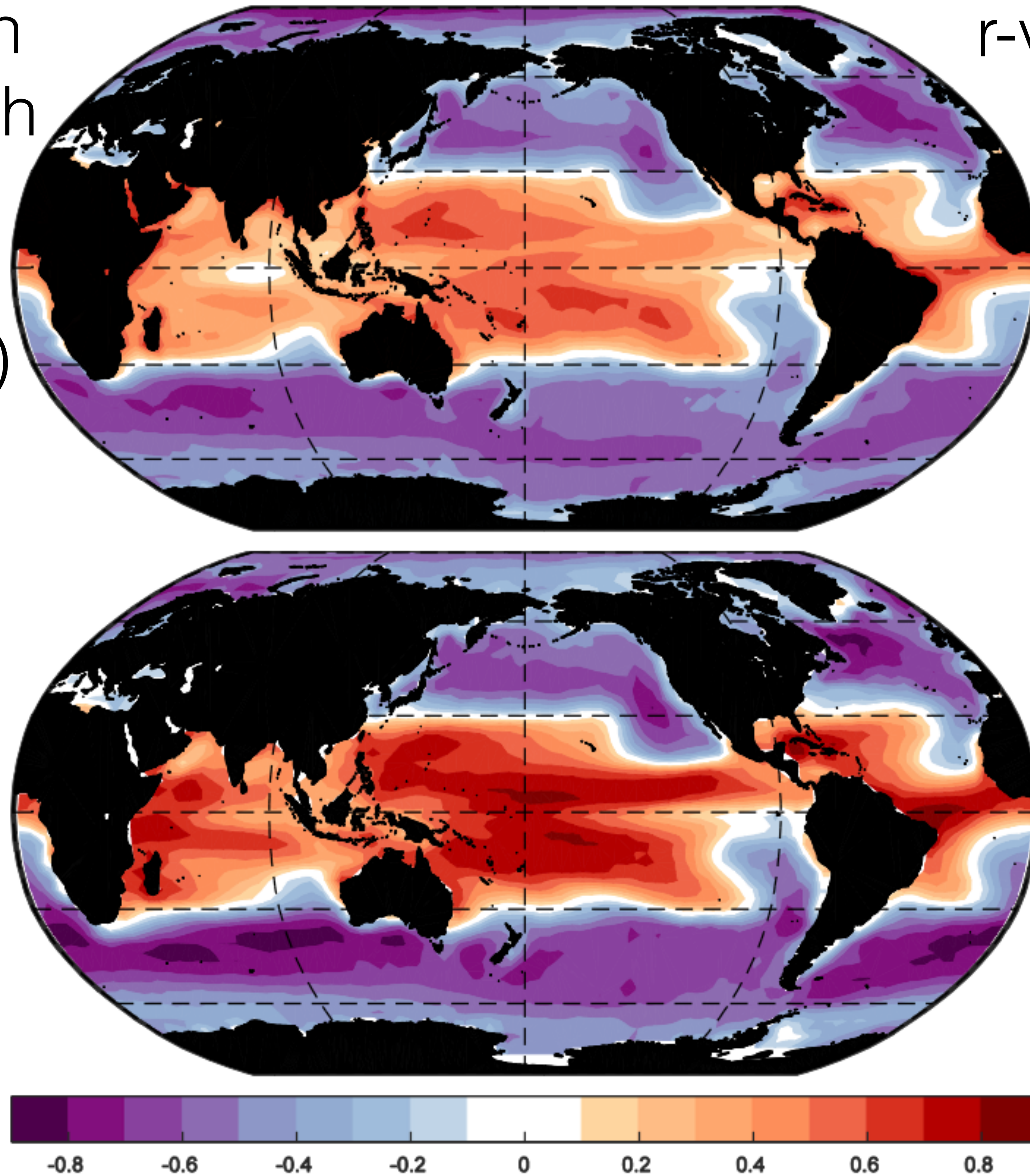


Constraint from SW CRE

r-value between SW CRE in each model and the global cloud feedback (PLS)

r-value between EOF and PLS exceeds 0.9

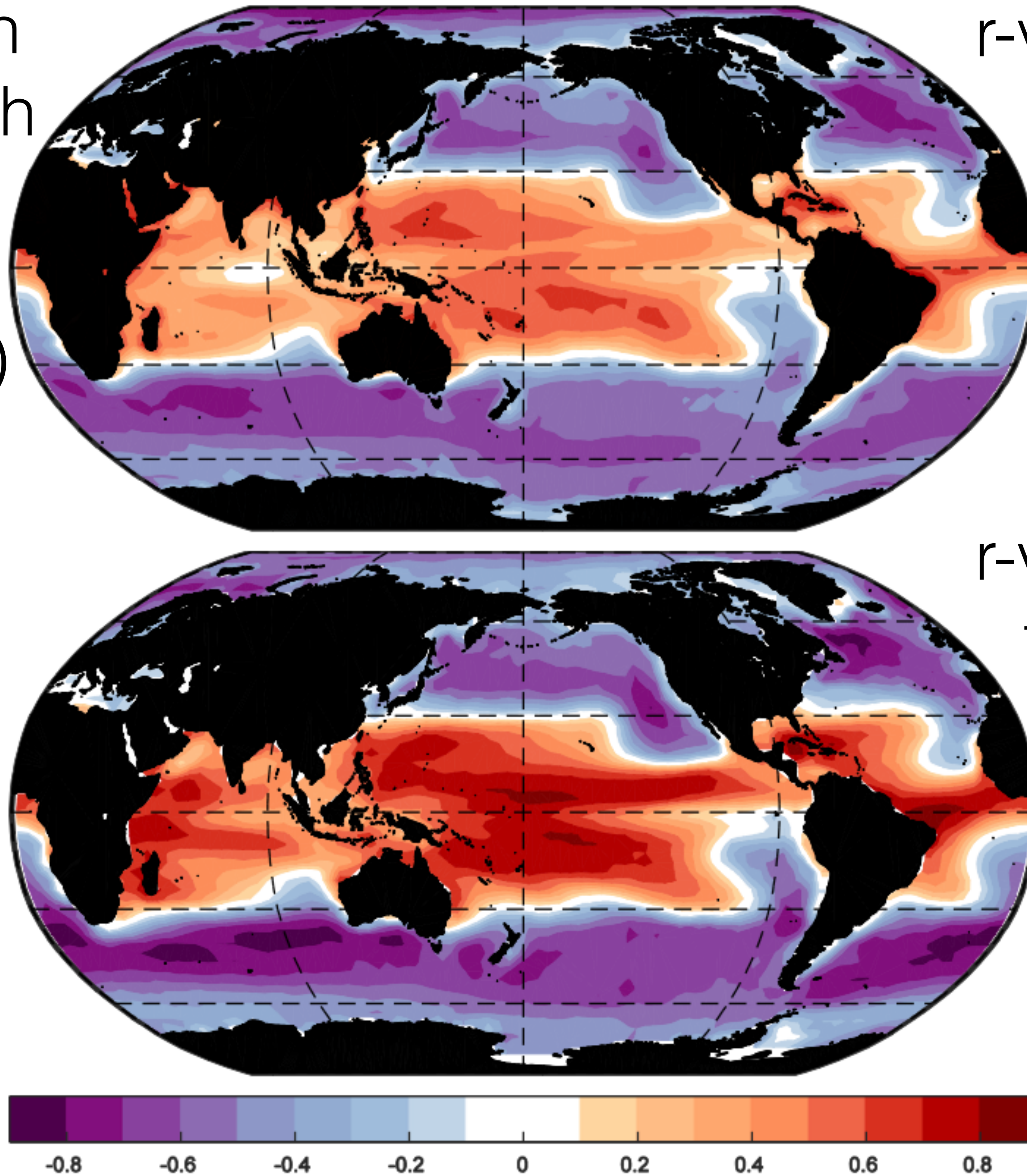
leading EOF of SW CRE



Constraint from SW CRE

r-value between SW CRE in each model and the global cloud feedback (PLS)

r-value between EOF and PLS exceeds 0.9



leading EOF of SW CRE

r-value between these patterns and the cloud feedback ~0.8

Constraint from SW CRE

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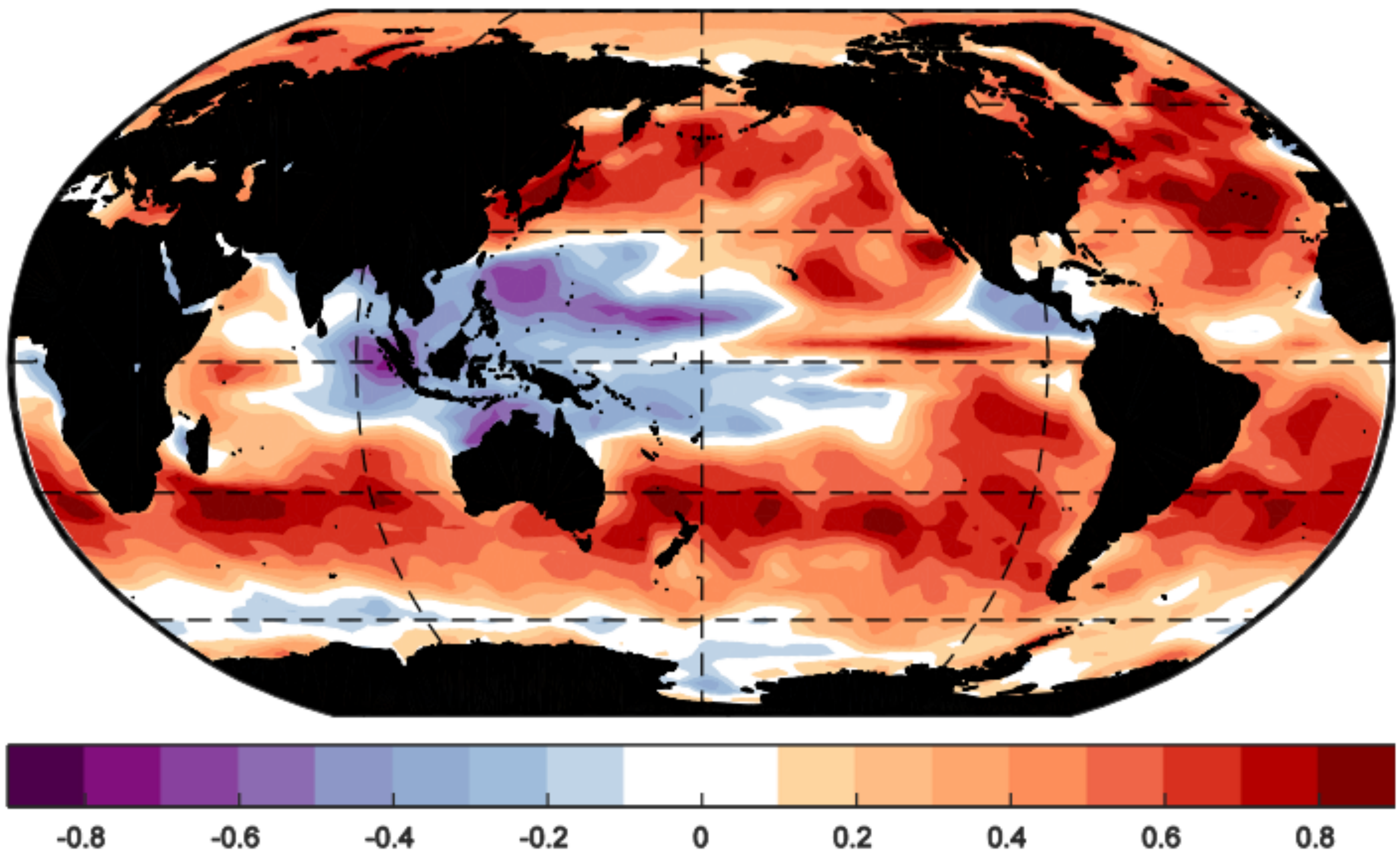
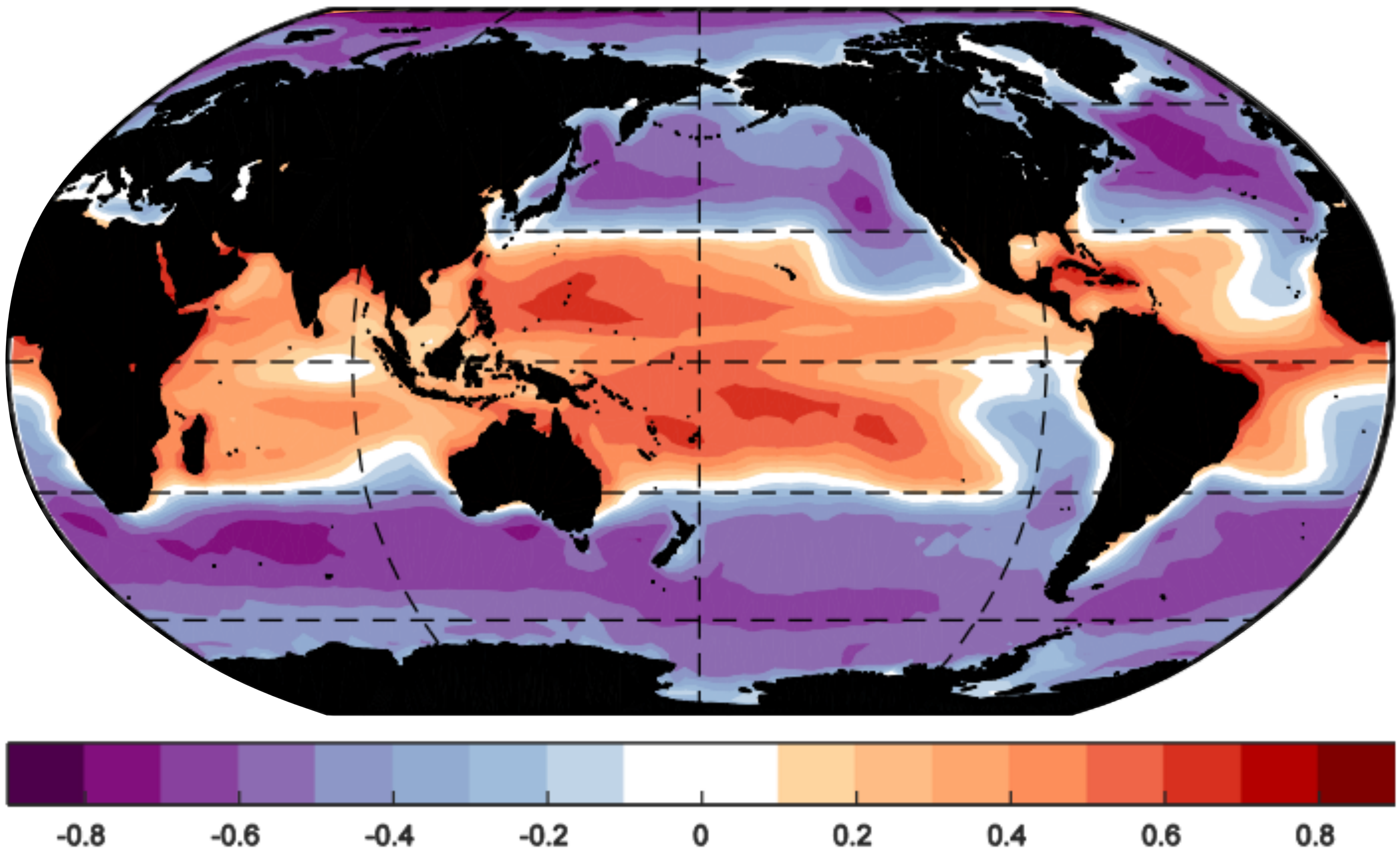


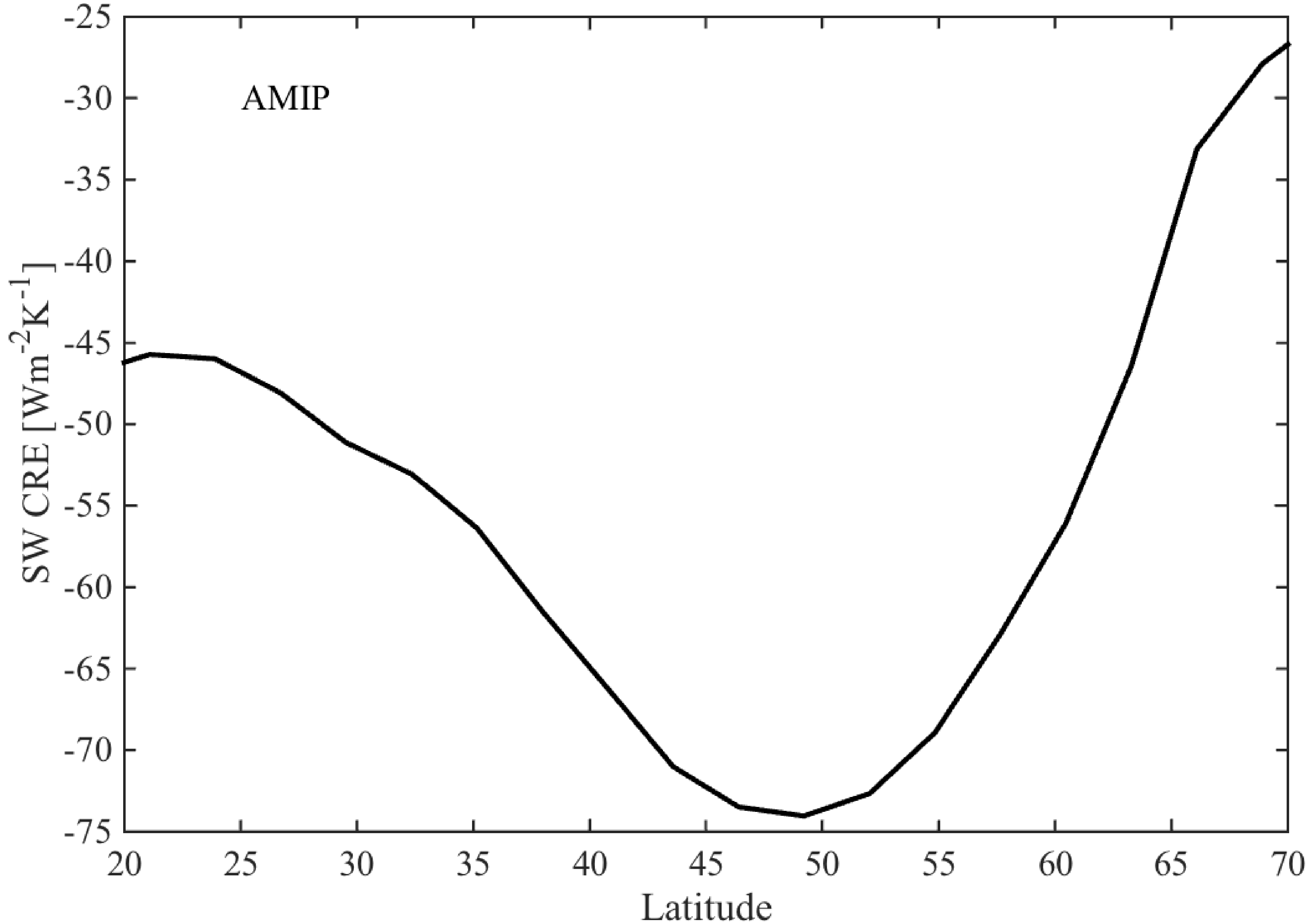
r-value between ΔSW CRE (amip4k - amip) and the global cloud feedback

Constraint from SW CRE

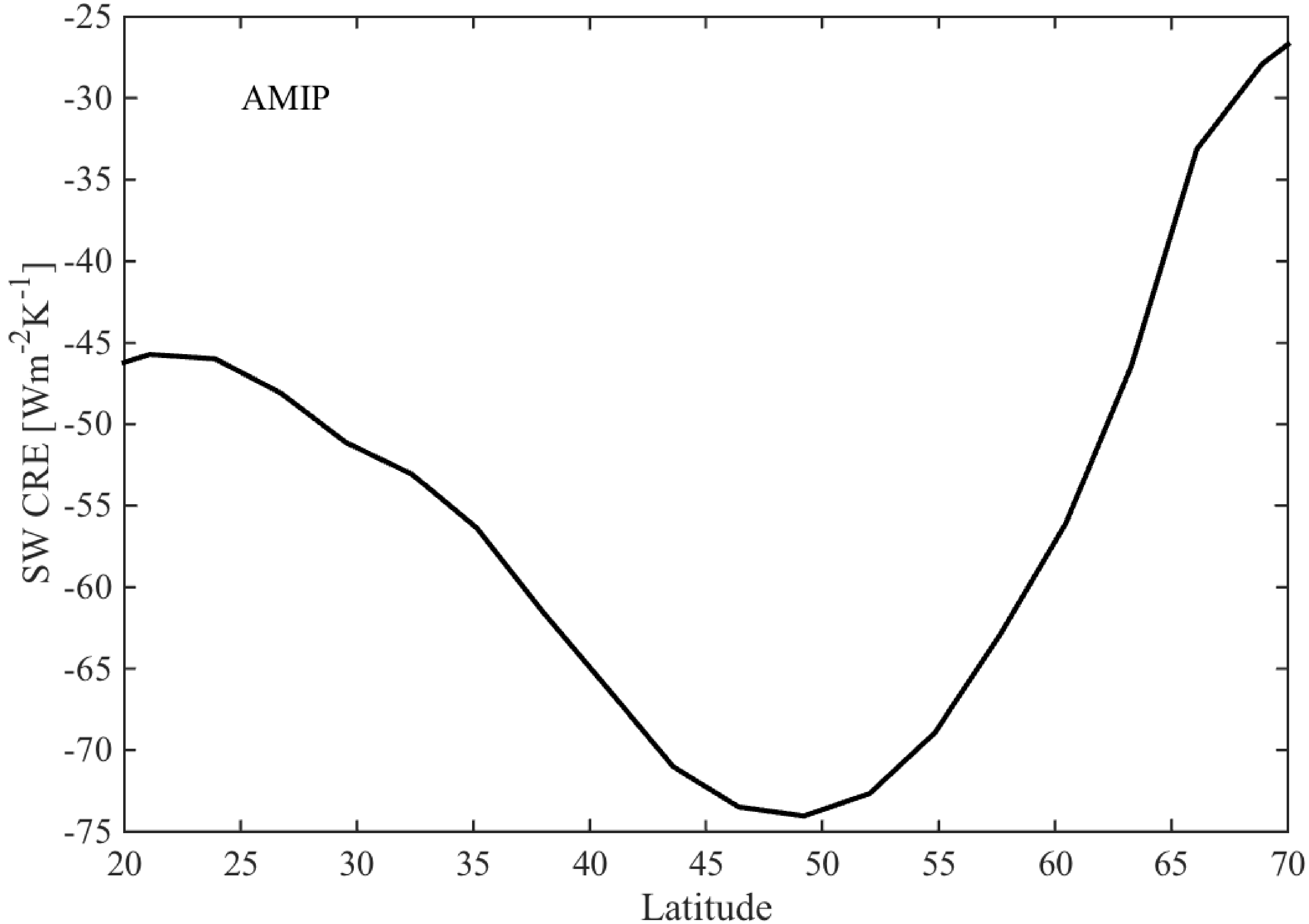


r-value between ΔSW CRE (amip4k - amip) and the global cloud feedback

Constraint from SW CRE



Constraint from SW CRE



Constraint from SW CRE

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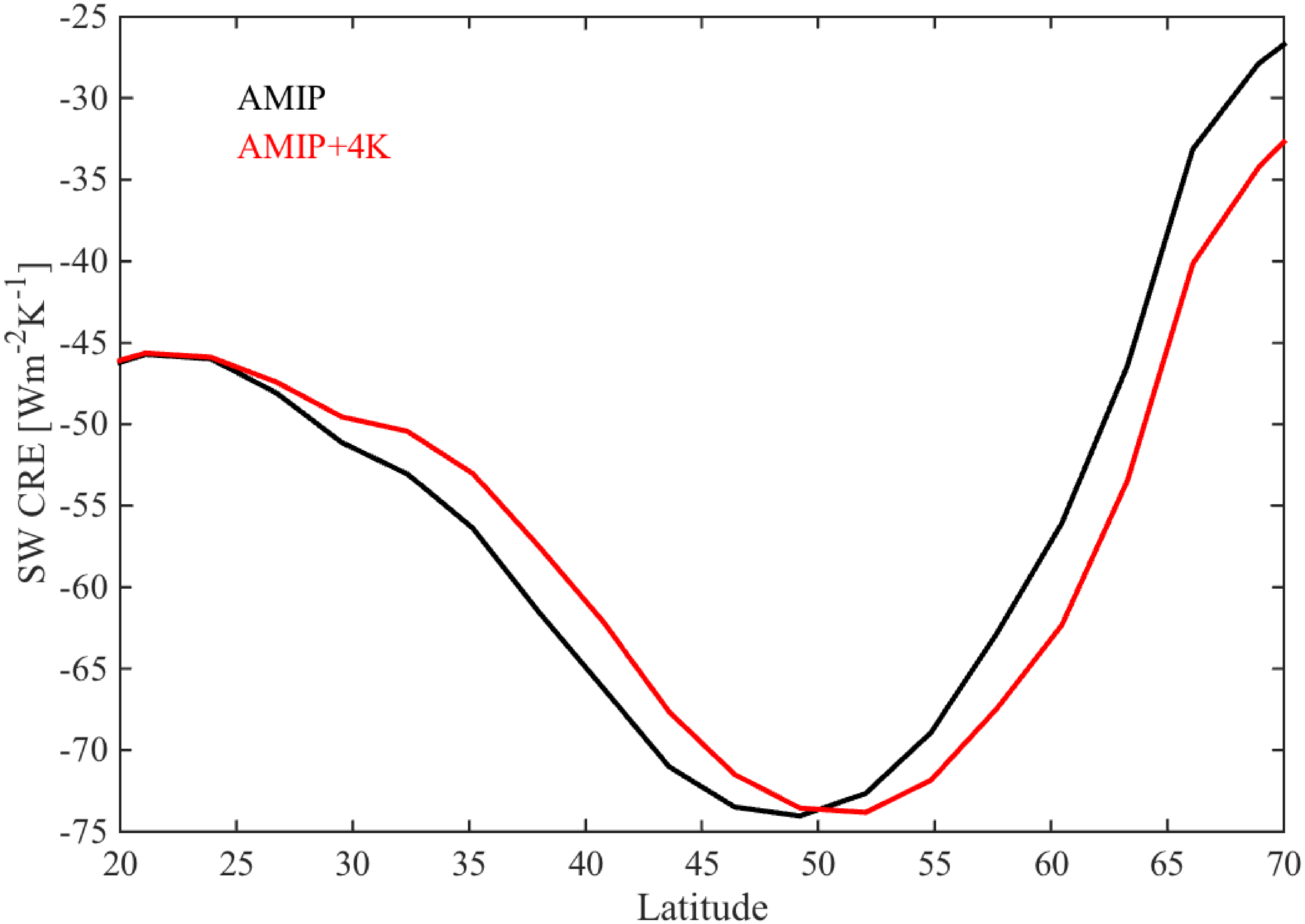
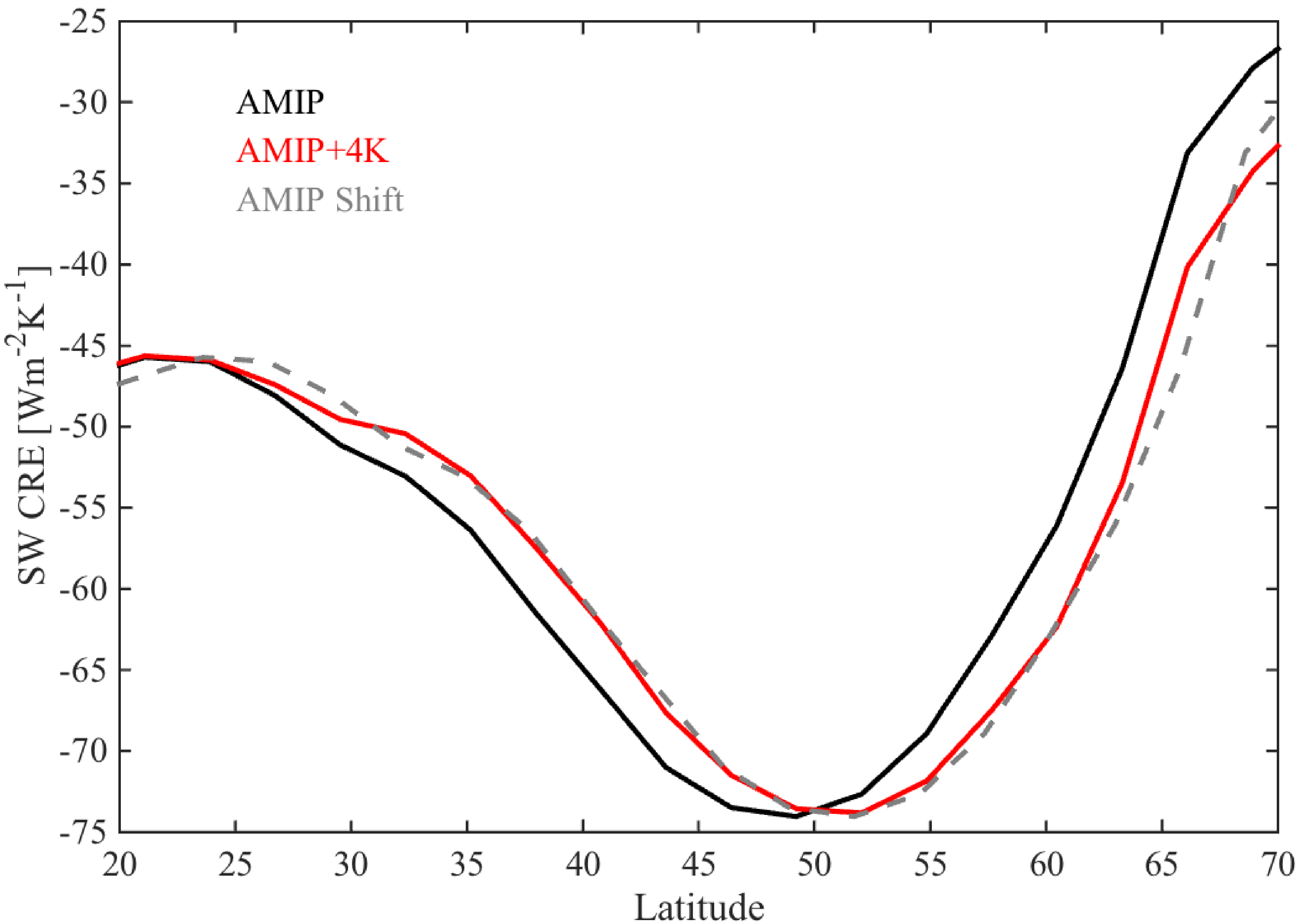
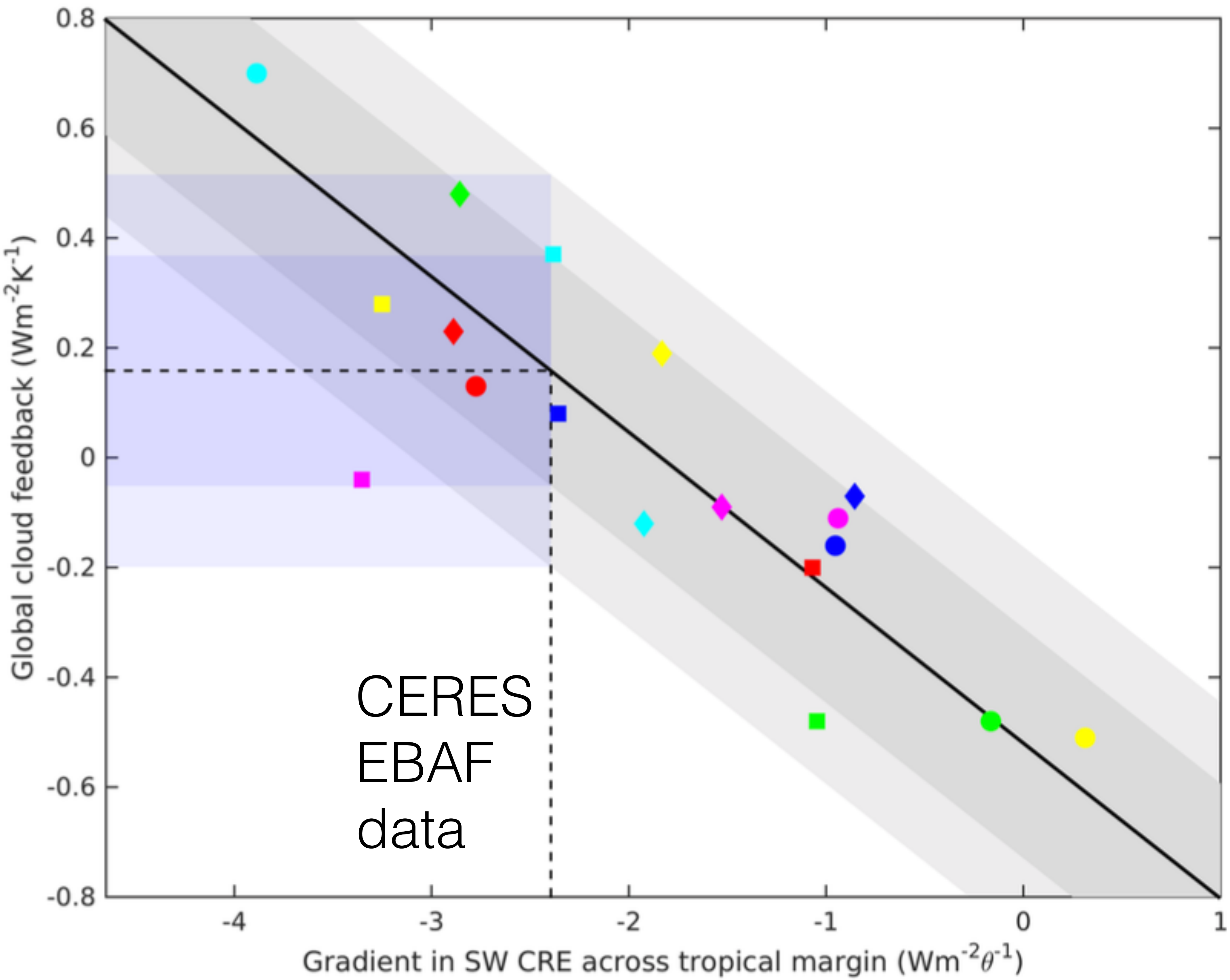


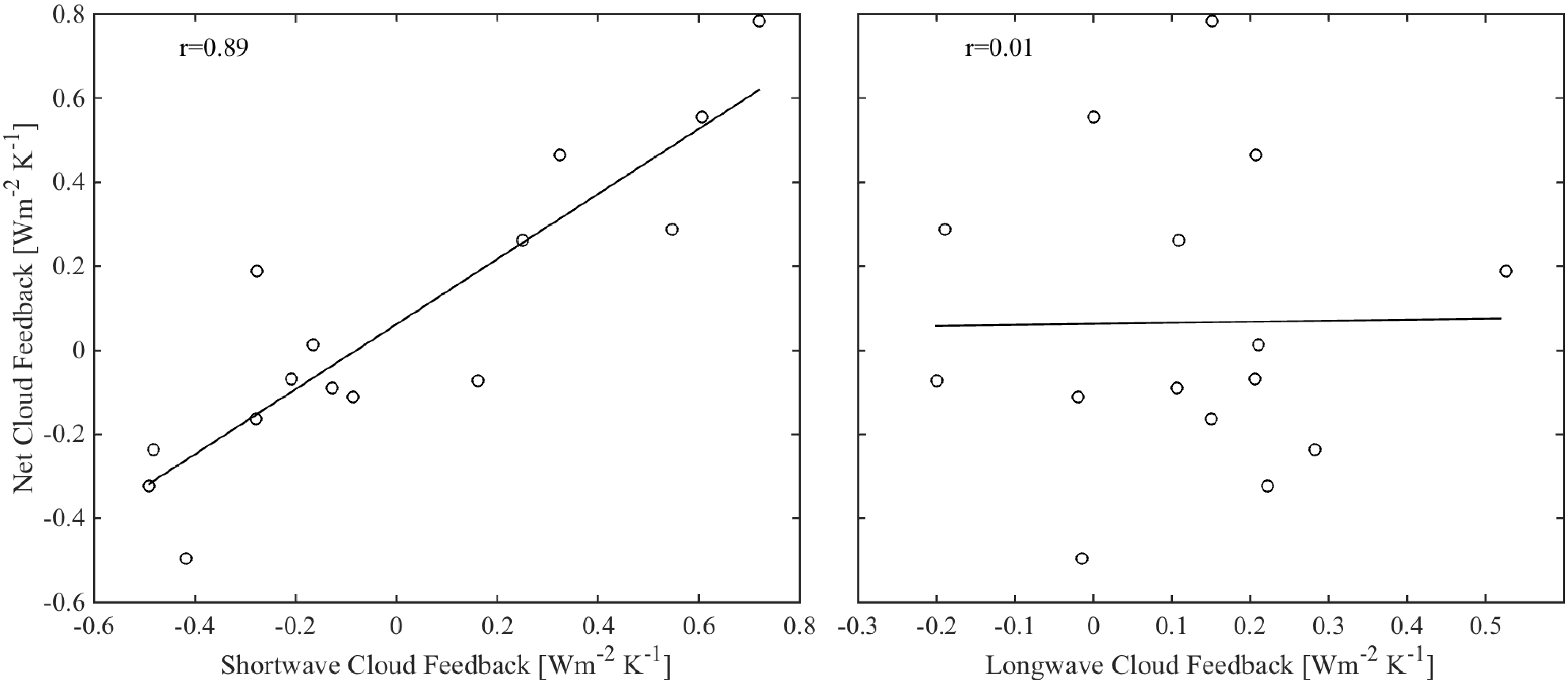
Constraint from SW CRE



Constraint from SW CRE

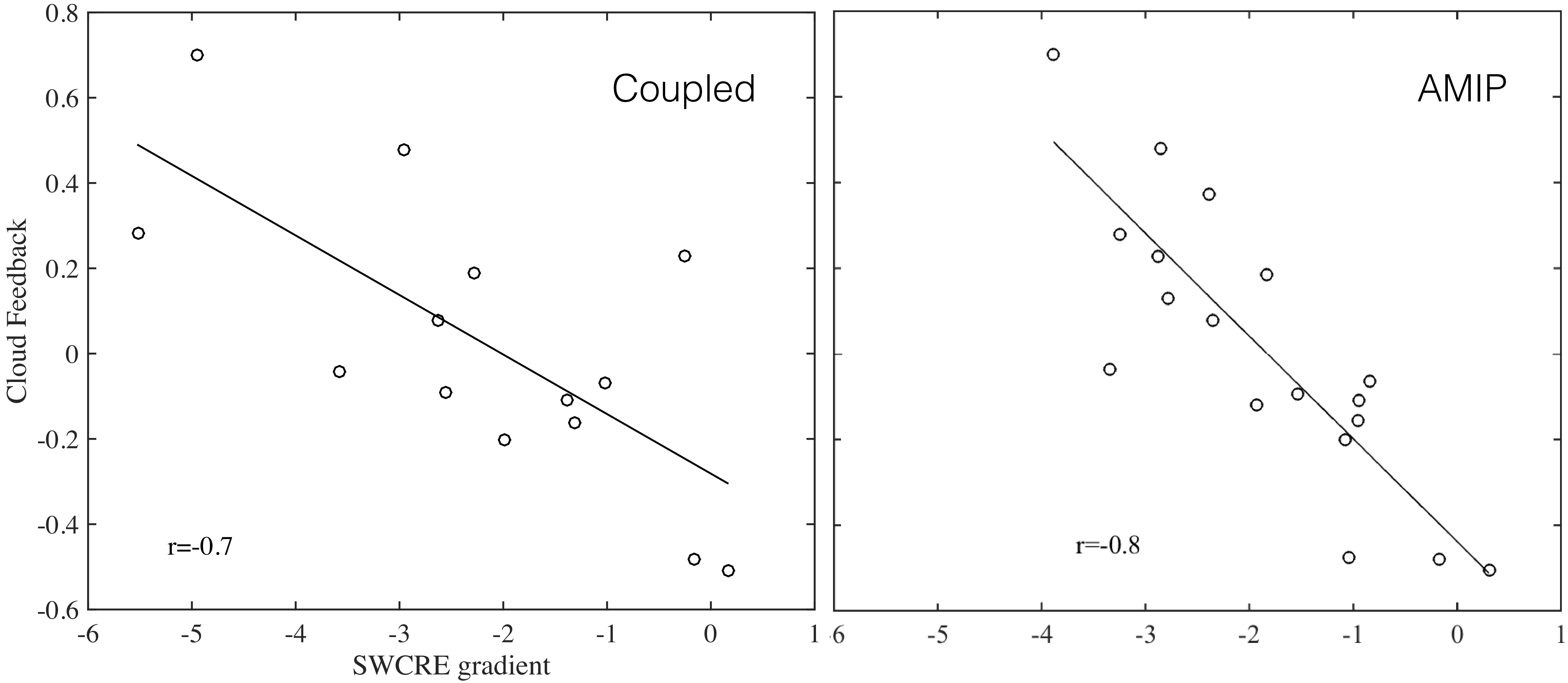


Comments



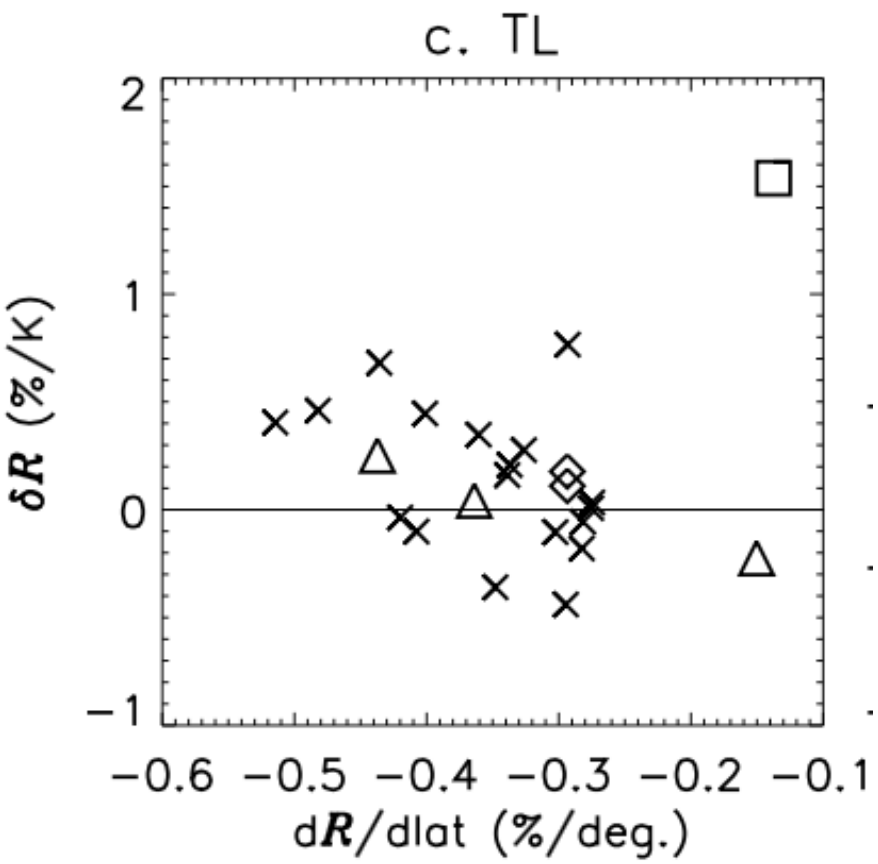
Shortwave cloud feedback dominates

Comments



Similar relationship in coupled models, though less strong (Hadley cell edge differs ~6^{o} across models)

Comments



Sherwood et al., 2010

Not a new idea, but not fully assembled

Comments

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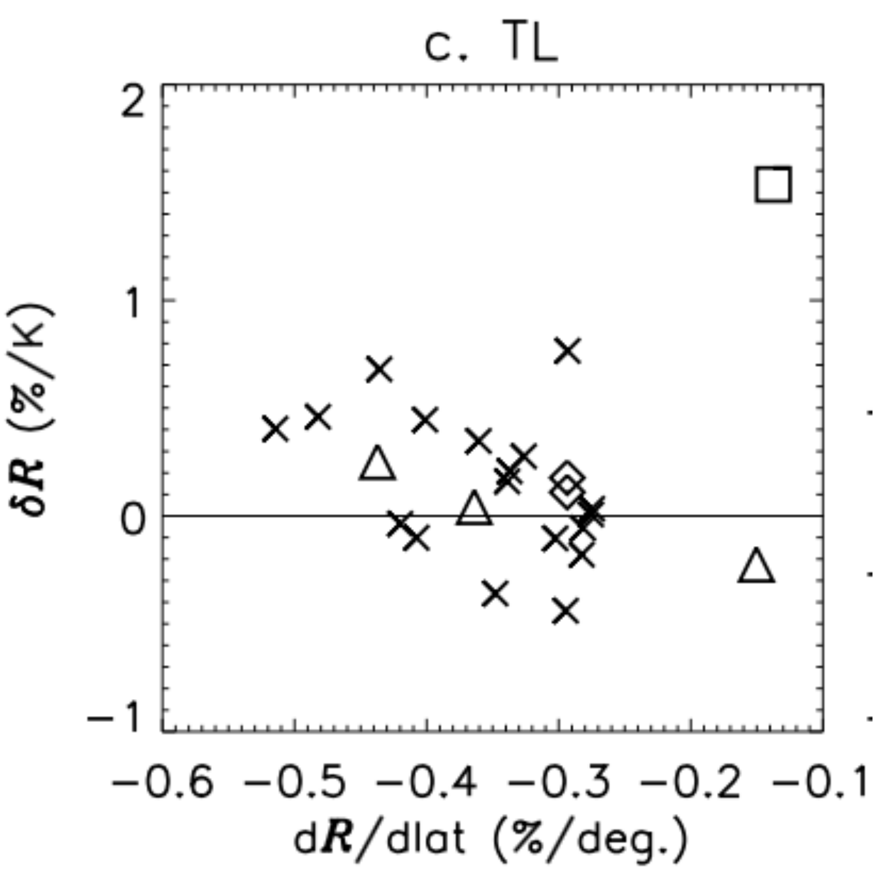
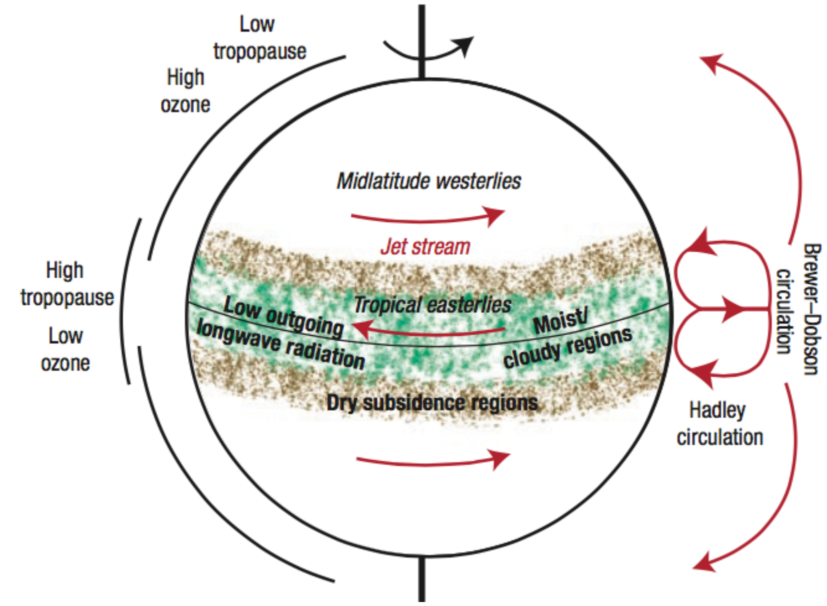
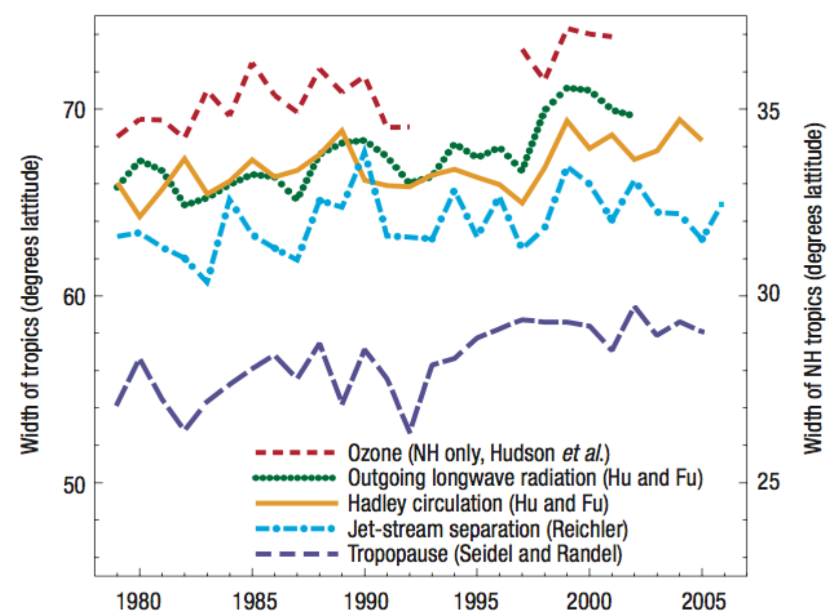


Sherwood et al., 2010

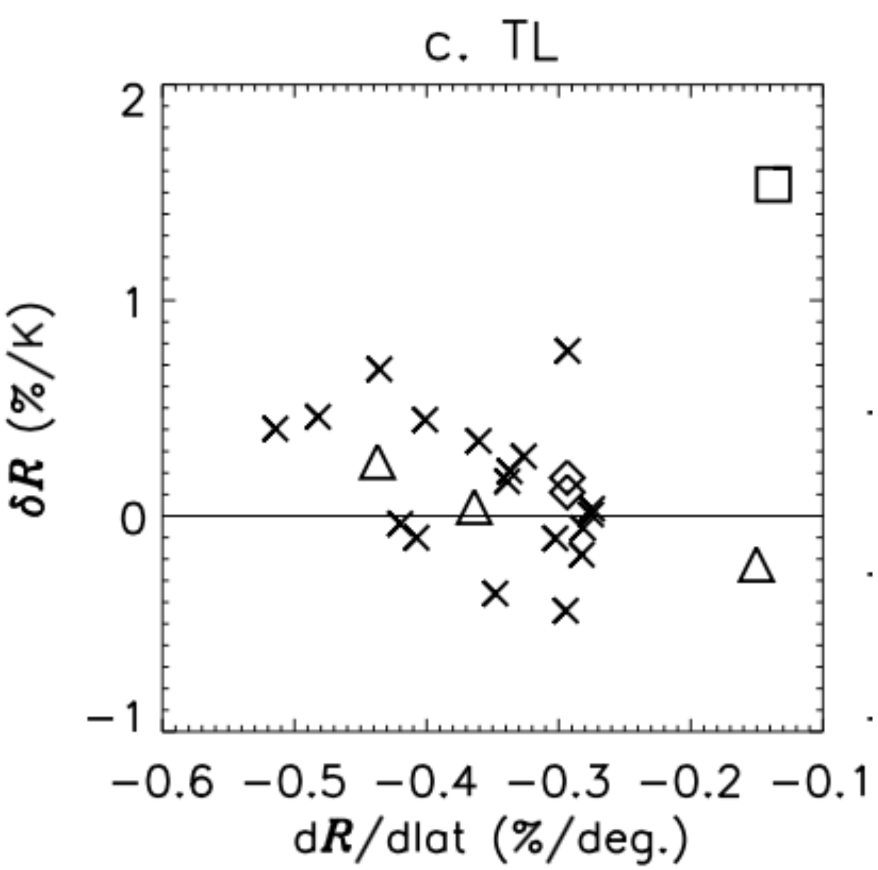




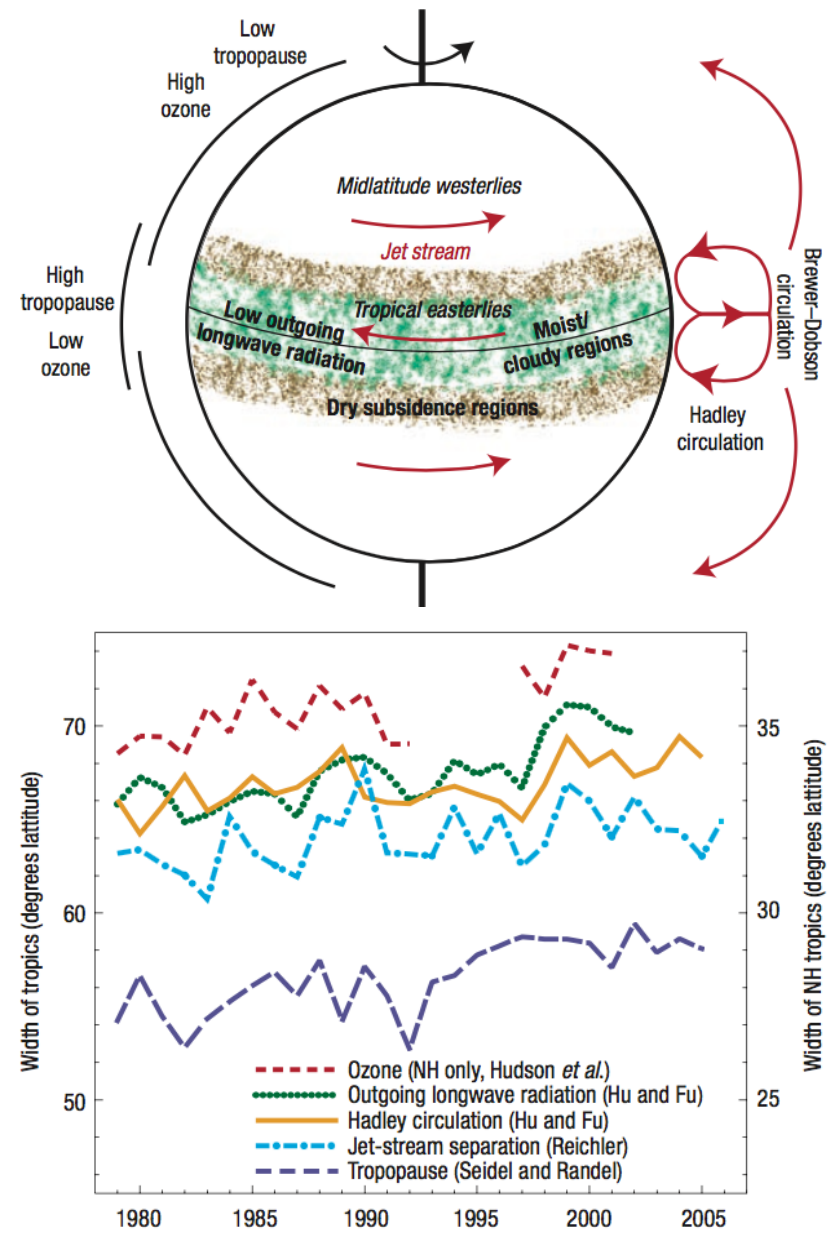
Seidel et al., 2008

Not a new idea, but not fully assembled

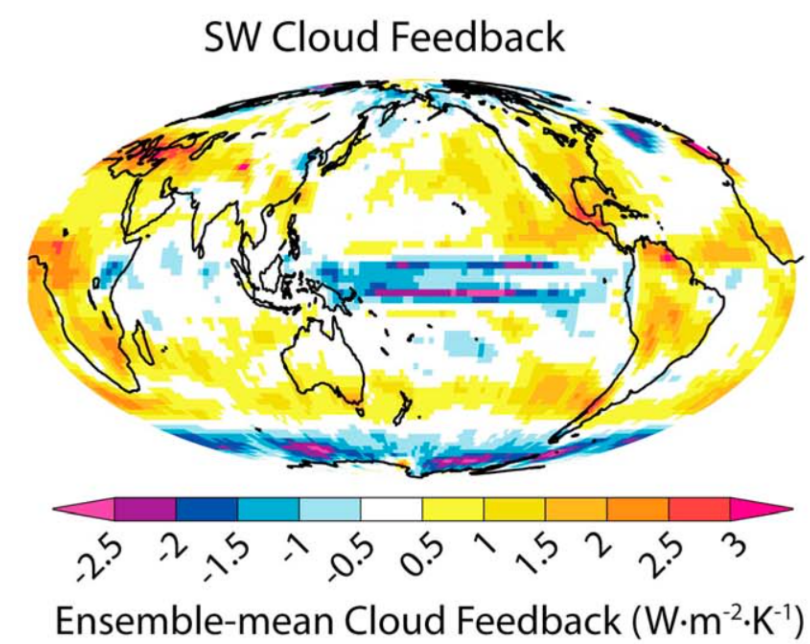
Comments



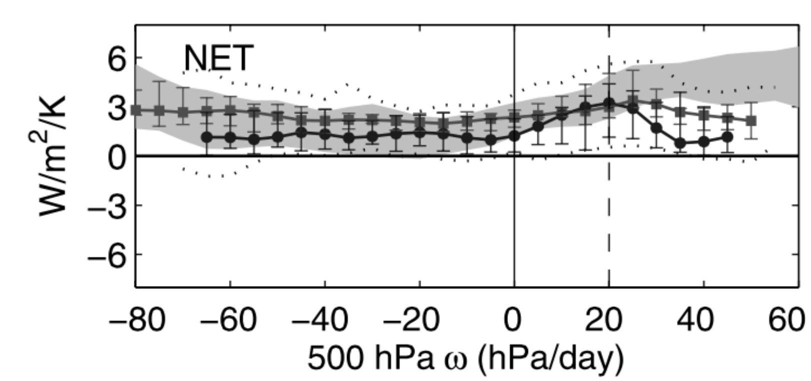
Sherwood et al., 2010



Seidel et al., 2008



Soden and Vecchi, 2011



Bony and DuFresne, 2005

Not a new idea, but not fully assembled

Comments

Comments

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Statistical significance of climate sensitivity predictors obtained by data mining

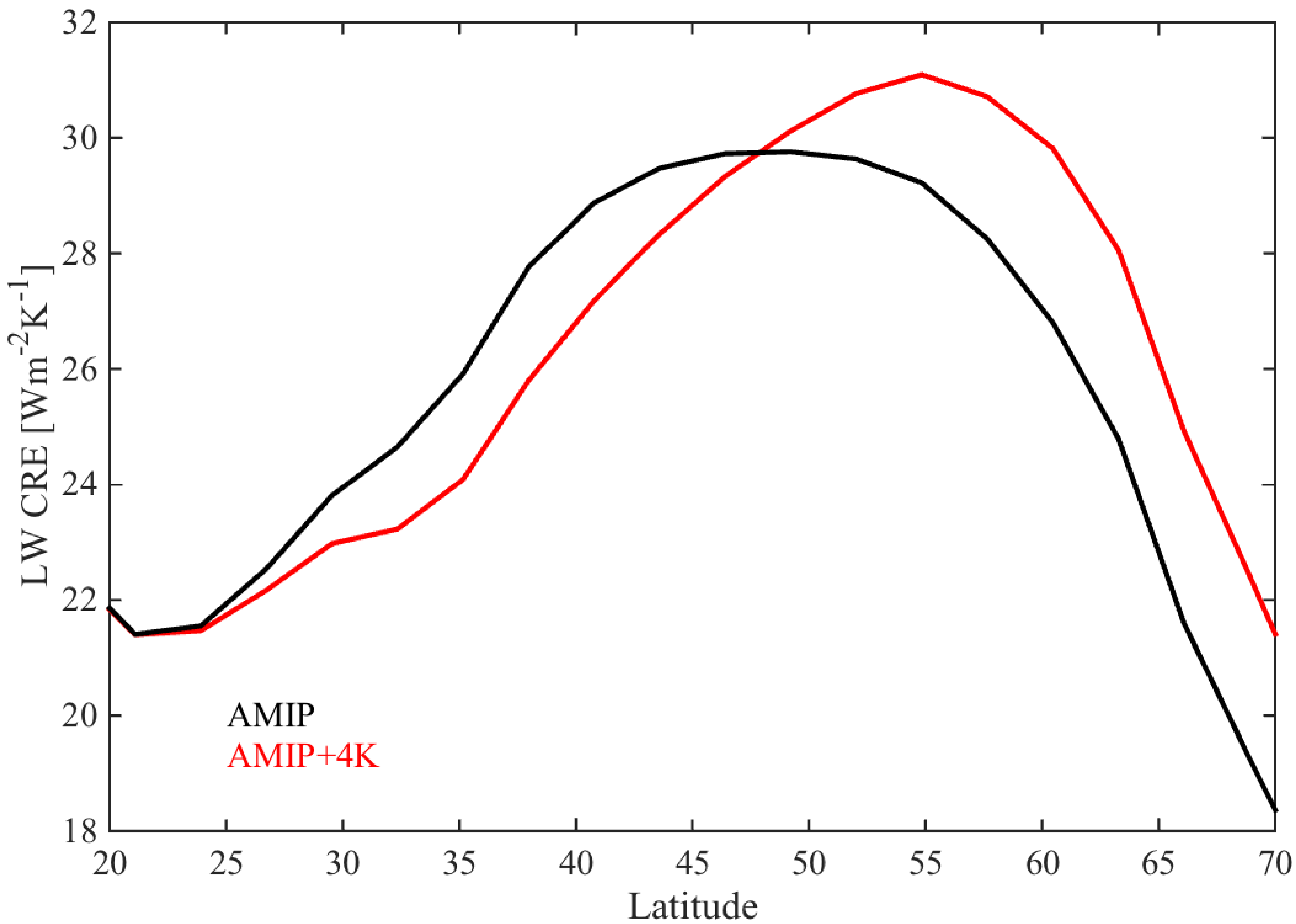
Peter M. Caldwell[1], Christopher S. Bretherton[2], Mark D. Zelinka[1], Stephen A. Klein[1], Benjamin D. Santer[1], and Benjamin M. Sanderson[3]

[1]Lawrence Livermore National Laboratory, Livermore, California, USA, [2]Department of Atmospheric Sciences, University of Washington, Seattle, Washington, USA, [3]National Center for Atmospheric Research, Boulder, Colorado, USA

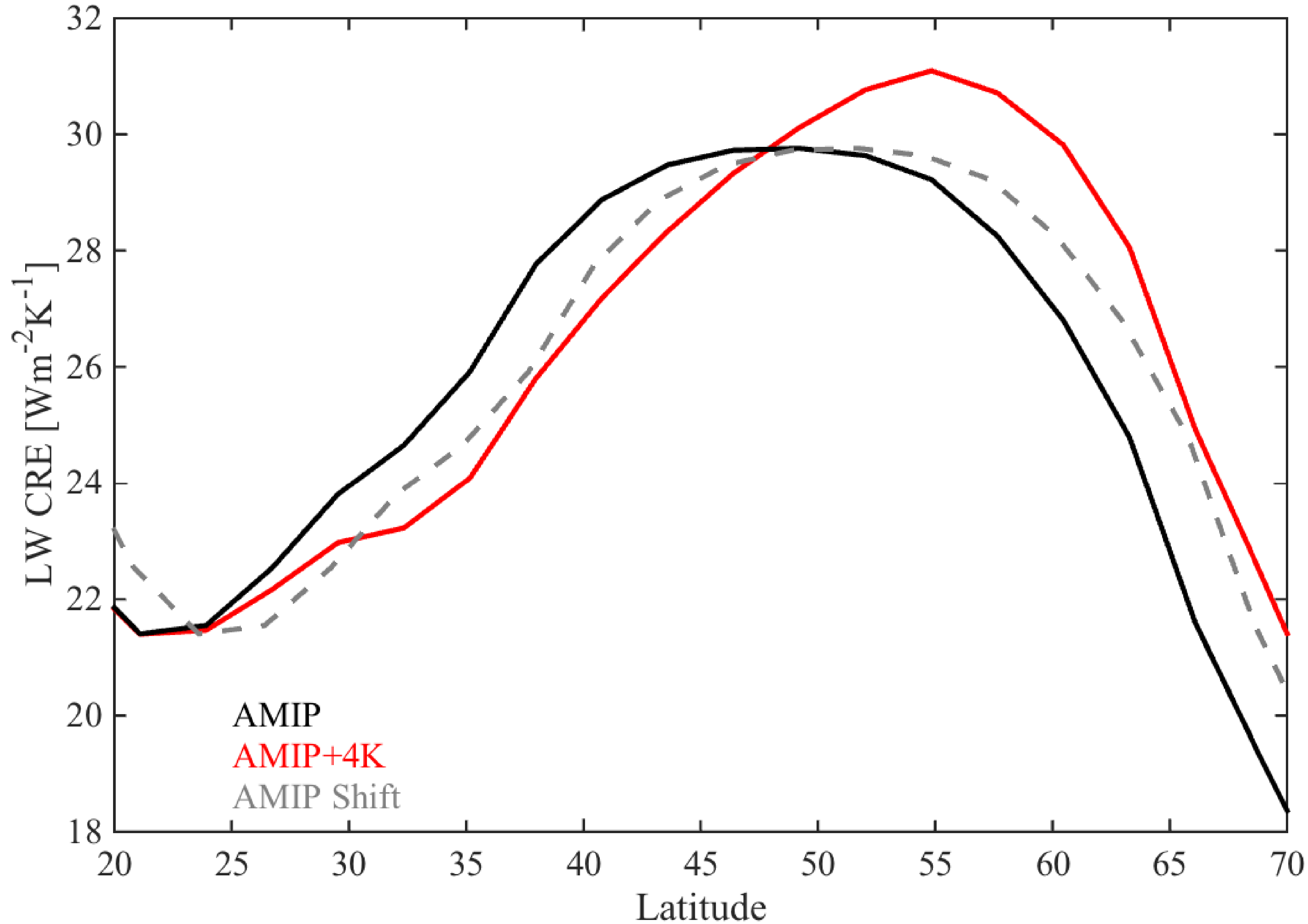
Abstract Several recent efforts to estimate Earth's equilibrium climate sensitivity (ECS) focus on identifying quantities in the current climate which are skillful predictors of ECS yet can be constrained by observations. This study automates the search for observable predictors using data from phase 5 of the Coupled Model Intercomparison Project. The primary focus of this paper is assessing statistical significance of the resulting predictive relationships. Failure to account for dependence between models, variables, locations, and seasons is shown to yield misleading results. A new technique for testing the field significance of data-mined correlations which avoids these problems is presented. Using this new approach, all 41,741 relationships we tested were found to be explainable by chance. This leads us to conclude that data mining is best used to identify potential relationships which are then validated or discarded using physically based hypothesis testing.

Summary

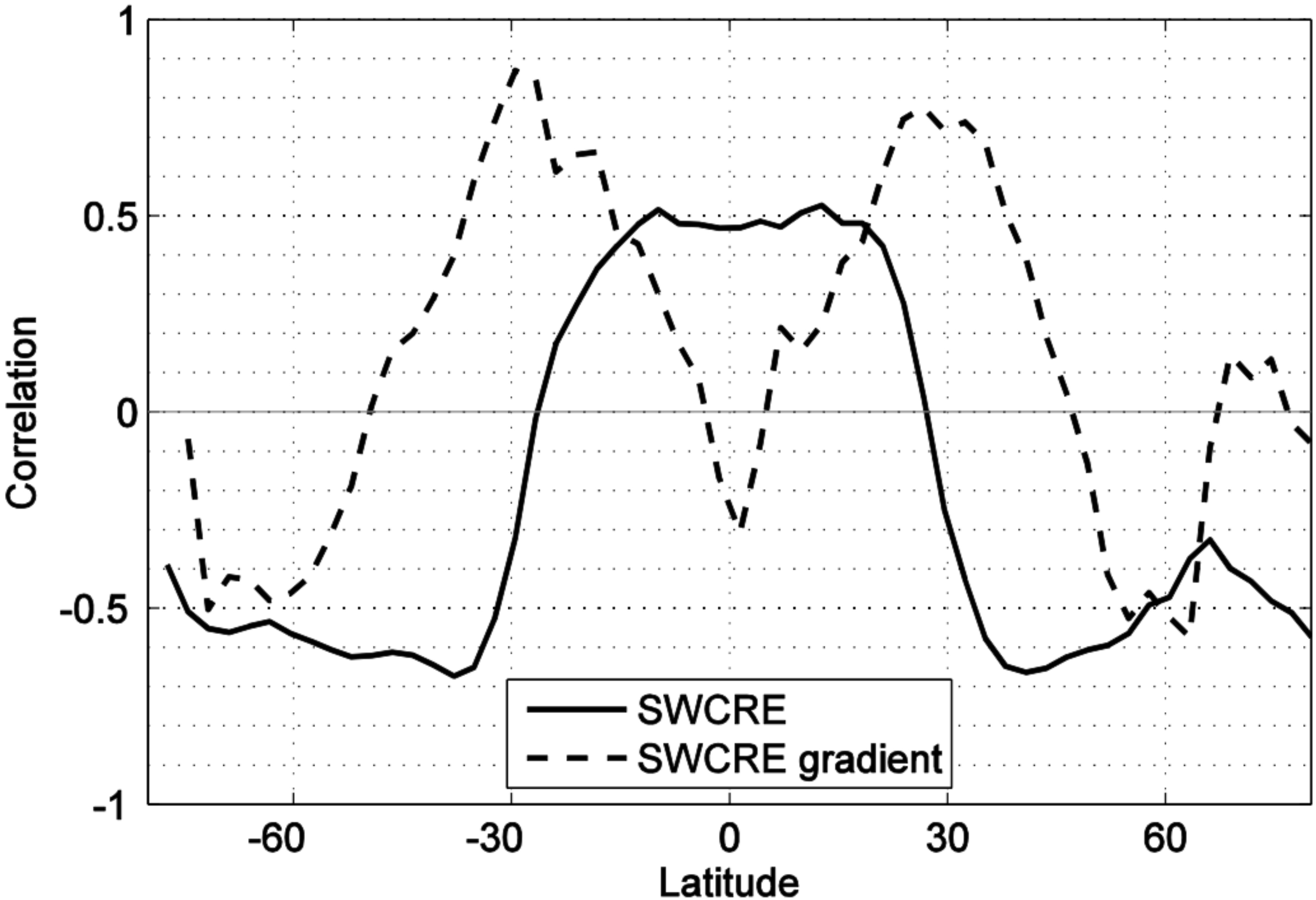
- AMIP models allow close spatial comparison of models
- Dipole in mean state SW CRE explains over 60% of cloud feedback
- Results suggest this is due to a expansion of the Hadley cell that shifts mean state SW CRE
- Variance in cloud feedback explained by gradient in SW CRE across subtropical margin
- CERES data suggests models with larger cloud feedbacks are closer to reality



32
30
28
26
24
22
20
18
LW CRE [Wm^{-2}K^{-1}]
20
25
30
35
40
45
50
55
60
65
70
Latitude
AMIP
AMIP+4K



AMIP
AMIP+4K
AMIP Shift
LW CRE [Wm^{-2}K^{-1}]
Latitude



1
0.5
0
-0.5
-1
Correlation
-60
-30
0
30
60
Latitude
SWCRE
SWCRE gradient

Correlation table

	PC 1	PC 2
ECS	.67	.56
Cloud FB	-.04	.76
CS FB	.60	-.06

- EOF 1 is related to Clear-sky feedback (contradicts Sherwood)
- EOF 2 is related to Cloud feedback